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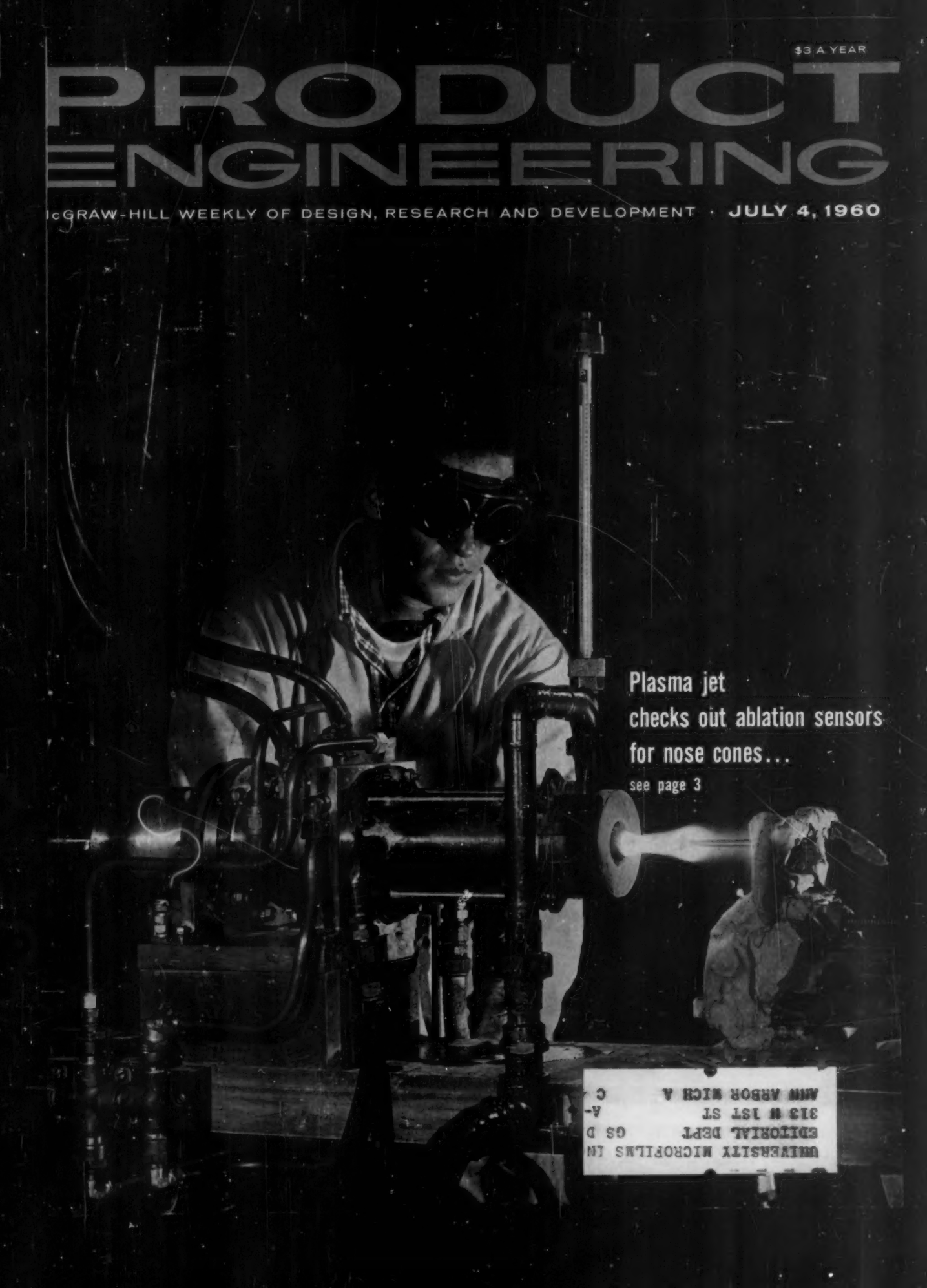
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · JULY 4, 1960



Plasma jet
checks out ablation sensors
for nose cones...
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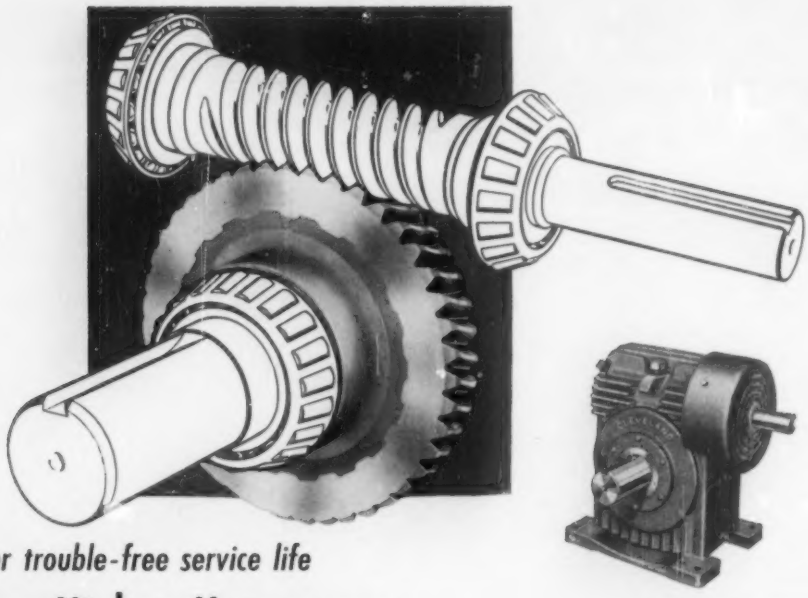

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...New Higher Horsepower Cleveland Speed Reducers feature centrifugally cast bronze gears

Providing higher input horsepower and output torque ratings, *New* Cleveland Speed Reducers now give industry dependable speed reduction at savings of 50% or more on per horsepower cost—without increasing size of the units.

Playing an important role in helping achieve these improved new ratings are Cleveland's centrifugally cast bronze gear rims of a high copper-tin-nickel alloy. When properly cast, this material provides highest strength compatible with requirements that it be free from abrasive crystalline components. Yet it's yielding enough to avoid excessive loading stress localization, while affording a low coefficient of friction against hardened steel—providing increased resistance to wear and fatigue pitting.

These rugged bronze rims are cast integrally with their supporting cast iron hubs (see photo at right). Checkered hub circumference holds the rim securely in position, making the two members independent of actual surface bond.

Also, another plus value of the New Cleveland Reducers is their especially large gear shaft diameters—which provide greatly increased overhung load carrying capacity.

For complete facts on this New Cleveland Speed Reducer Line, consult your local Cleveland Representative. Or, write us direct for free Bulletin No. 405—it gives *complete* engineering information for designers and engineers.

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McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

July 4, 1960 Vol. 31, No. 27

FEATURED:

DEPARTMENTS:

INTERESTING TO NOTE 3
COMING NEXT WEEK 4
DEVELOPMENTS TO WATCH 6
WHAT'S NEW IN RESEARCH 10
FROM WASHINGTON 12
THE ENGINEERING WEEK 15
POINTS OF VIEW 20
READER TO EDITOR 22
FYI PERSONAL 23
HORIZONS 25
PRODUCT DESIGNS 33
SIGNIFICANT COMPONENTS 52
DESIGN LITERATURE 63
ADVERTISERS INDEX 68
READER SERVICE CARDS 69

DEMAGNETIZE BEFORE ASSEMBLY . . . J N Engelsted, O S Walker Company
It's more important than you may think—here's why . . . 27

TODAY'S CHROME PLATE FINISHES . . . F Giordano, Detroit editor
Corrosion resistance increases with the duplex chromes and nickels . . . 36

HOW TO DESIGN LIGHTWEIGHT CASTINGS . . . H R Bullock, Raytheon Co
Step-by-step procedure for Space Age applications . . . 39

GET YOUR SHARE FROM TECHNICAL LITERATURE . . . H S Sharp
How to check on possible solutions to your problem . . . 40

SOLID ALUMINUM BEARINGS . . . D B Wood, Alcoa
For best results when designing with the lightweight metal . . . 42

FINDING FOCAL LENGTH OF A THICK LENS . . . D H Cronquist
You can then determine principal points of the lens . . . 49

FIELDS OF INTEREST REPRESENTED IN DEPARTMENTS:

MATERIALS:
This tungsten alloy is claimed to be strong and stable . . . 8
The noble gases solve design problems . . . 8
Research promises better cold-drawn steel . . . 10
Metal strength sometimes sapped by "protective" atmospheres . . . 10

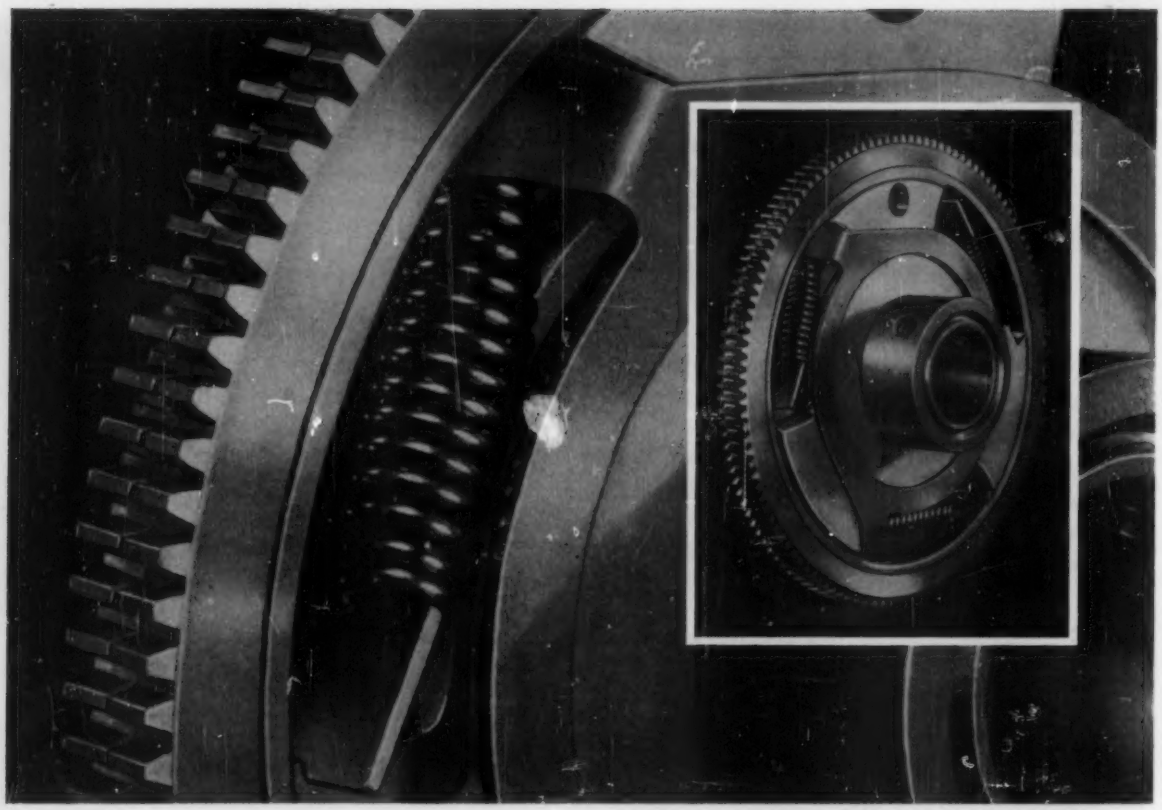
MECHANICAL:
Drive with coarse-fine gearing devised in West Germany . . . 8
Centrifugal clutch can be adjusted for max torque . . . 52
Packless valve handles unfiltered liquids . . . 54

ELECTRICAL:
A simplified sine/cosine potentiometer . . . 6
Rectifiers hold key to magnetic-amplifier development . . . 6
US pushes research on organic semiconductors . . . 10
Toggle switch breaks circuit when overloads occur . . . 52
Angular motion transducer has linearity better than 0.25% . . . 54

PRODUCT DESIGN:
New cargo plane is object of design competition . . . 12
Spray cools black boxes . . . 33
Amplified muscle gives control . . . 34
Brazed engine offers raised performance . . . 35

PROCESSES:
Sound waves help cladding of metal . . . 6
Chevy casts aluminum by low-pressure method . . . 16

GENERAL:
Our cover picture—details on Avco's plasma generator . . . 3
First patent granted to private company for reactor system . . . 10
Defense dept shopping overseas for its R&D . . . 15



G.S. gives you NON-SPREAD CONTROL for preloaded Gears with this patented "*SPRING-GRIP*" construction . . .

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The illustration shows how this *"Spring-Grip"* feature is applied to a Worm Gear; one of the twin elements is fixed to the hub, the other is free to rotate within limits controlled by the springs. G.S. *"Spring-Grip"* construction is also available in straight or helical Spur Gears.

We can also supply other styles of preloaded Gears with compression-type coil springs, torsion or loop springs, to fit varying needs. All are made with the famous G.S. precision and rigid quality control, assuring the accurate tooth profiles so essential in the intimate contact occurring with anti-backlash Gearing.

G.S. specialized experience, broad line, and unsurpassed engineering and manufacturing resources—the most extensive in its field—can help solve *your* Fractional Horsepower Gear problems too. Call us in to discuss them!

SEND FOR G.S. *illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

44 Years of Specializing in Small Gearing!

INTERESTING TO NOTE

On our cover – a plasma generator developed by Avco Research and Advanced Development Div, Wilmington, Mass. To many, the term "plasma generator" might seem more fitting for a device in a hospital's operating room. However, as man makes deeper inroads toward the unknown, terms have to be borrowed from all aspects of science.

The plasma being hurled by the device on our cover is certainly an amorphous, chaotic material, as the term indicates. But it is an amorphous mass of molecular fragments–not of blood elements. Its importance is that it's a high-energy, high-pressure stream of fragments, of the type encountered by hypersonic missiles reentering our atmosphere.

Avco has built several of these generators. The first was water-stabilized and had carbon electrodes. Latest model is the one on our cover. It has a carbon cathode and watercooled copper anode–an arrangement that has reduced electrode contamination.

Temperature of the plasma can be programed by changing the rate of gas flow; the diameter of the plasma jet can be varied from 0.25 to 2.0 in. by changing the exit-nozzle component. In terms of power and size, a 2-kw unit can be used for ceramic spray-coating applications while a 10-million-watt "wind tunnel" can test high-temperature materials.

All that Glitters . . .

During the mid-1760s, a geologist in Siberia happened to pick up a pretty, hyacinth-red rock. Its composition baffled him, so he took it along. Back in civilization, he took it to a chemist for analysis–it turned out to be "an unknown mineral containing a crystallized lead salt" and it was named crocoite, or Siberian red lead. Thirty years elapsed before another chemist, L. N. Vauquelin, obtained samples of crocoite and heated it in a crucible. To his surprise, needles of a silvery metal began adhering to the crucible's sides. He next treated this glistening metal with various acids and reagents. Upon doing so, he was impressed by the well-defined colors of red, yellow and green that appeared in his solutions. Vauquelin had discovered a new element and proceeded to name it after the Greek word "chroma," meaning color.

It didn't take chromium long to find its way to the marketplace in the form of pigment replacing poisonous arsenic in various paints. Princess Charlotte, daughter of England's King George IV, was so impressed with the brillance of chrome yellow that she ordered her royal

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coach repainted—this may have been the world's first "yellow cab." The number of applications for chromium grew rapidly. One of the largest, chrome plating, is discussed on page 36.

Then, in 1811, Isaac Tyson, son of a wealthy Baltimore grain exporter, was handed a rock by the family gardener with the explanation, "This is just like the chromite ore we used to mine in the old country." It didn't take young Tyson long to put two and two together, but the chromite pits on his family estate were quickly exhausted. Sixteen years passed before Tyson again saw chromite ore; this time it was being used to hold down the lid of a cider barrel on a farmer's cart. He questioned the farmer. Quickly tracing the rock to its source, near Jarrettsville, Md., he bought up all the nearby land containing potential chromite mines. Tyson soon became a millionaire and, for a time, America became the world's center of chromite ore.

Some Attractive Theories

When the plague hit London in 1603, more than 30,000 people lost their lives. One of them was a scientific dabbler and former president of the Royal College of Physicians, William Gilbert. Sixty-three years after his death, all Gilbert's instruments, books, and manuscripts, which had been turned over to the Royal College of Physicians, were lost in the great London fire. Only a thin book, published three years prior to his death, remained to perpetuate Gilbert's name and allow him a front-row seat in the gallery of scientific greats.

In this book, *De Magnete*, Gilbert described nearly twenty years of intensive experimentation with all the bodies then known to have magnetic and electric properties. By actually performing each experiment he described, Gilbert initiated a methodical scientific pattern that helped usher in the scientific revolution. Gilbert, for example, was the first to suggest that the earth is like the lodestone: a giant magnet. For centuries, only one electrical phenomenon had been generally accepted as factual—amber (and jet), when rubbed, attract light objects.

Gilbert's discoveries would seem elementary to most schoolboys today, but in the 16th century the only connection anyone had with electricity was the lodestone, then used in making the mariner's compass. The effects of magnets upon various objects (page 27) was the heart of Gilbert's studies. He found that moisture hinders electrification; that electrified bodies attract metals, liquids and even smoke; that there are two general classifications —electrics and nonelectrics. Obviously many of these basic observations were refined when later-day explorers used Gilbert's experiments as steppingstones to understanding more about the electrical sciences. Thus this early English physician, who published the first treatise on electricity, opened the gate for Volta, Ampere, Faraday, et al.

—Benedict A Leerburger Jr

From "De Magnete," 1600

A magnet is formed by pounding hot iron in the north (septentrio) and south (auster) direction.

NEXT WEEK IN PRODUCT ENGINEERING

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Versatile wax-filled thermal controls are now competing successfully with conventional liquid-and-gas-filled bulb and bellows actuators.

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A covering of molded resin and fiberglass keeps wires from running wild and provides a rigid bundle that effectively resists abuse.

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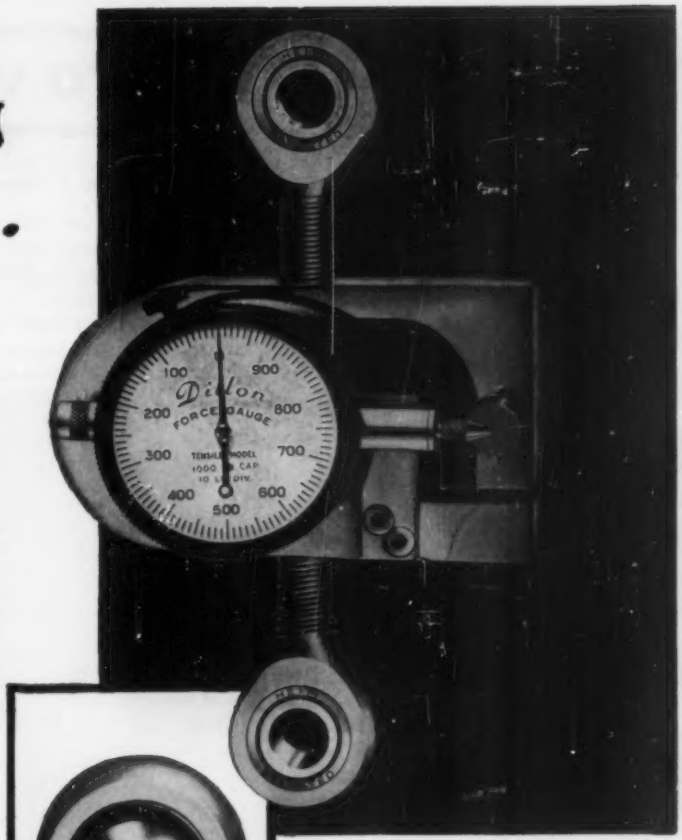
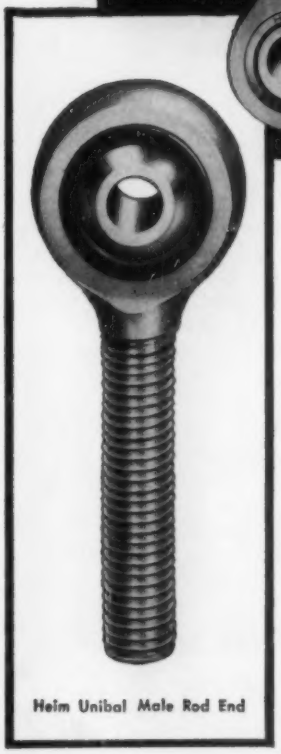
. . . **Springs: How to Design for Variable Rate**
Eighteen diagrams that show how stops, cams, linkages and other arrangements can vary the load-deflection ratio during extension or compression.

This Success is No Secret...

The Dillon Mechanical Force Gauge is used for precision measurement of pressure, tensile or torque. For ease in applying load to tensile models, Unibal rod end bearings are attached to each leg of the alloy steel bar. If an oscillating, push-pull motion must be measured, both the compressive load and the tensile load are applied through Unibal rod ends.





Heim Unibal Male Rod End

In this case, an instrument calibrated 180 degrees in compression (reading clockwise), and 180 degrees in tensile (reading counterclockwise) is required.

Here is a true success story of a device, built with watchmaker's precision, which is designed to check all such loads, even in limited space.

It is no secret that the

HEIM *Unibal*® SPHERICAL BEARING ROD END

contributes to the successful operation of the Dillon Force Gauge. Two Unibal male-threaded rod ends are attached to the pressure bar. Calibration in both tensile and compression is conducted against a pin placed through the Unibal, or eye, of the rod end.

Heim Unibal corrects misalignment in every direction, reduces friction, carries maximum loads, saves time and money in assembly.

All Heim bearings are available through the leading bearing distributors in the U. S. and Canada. Send for complete catalog with distributors' names and locations.

THE HEIM COMPANY

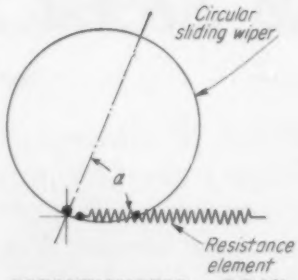
FAIRFIELD, CONNECTICUT

DEVELOPMENTS TO WATCH...

Simplified sine/cosine potentiometer unveiled in Canada

Resistance is a linear function of the sine or cosine of the angle of shaft rotation in a potentiometer developed by a Canadian, William C. Brown. No gearing or variable wire spacing is required. A circular wiper moves over a straight-line resistance element, and is pivoted at a point on its circumference over one end of the resistance element. Since the wiper is insulated from the winding at the pivot, the length of the active resistance element varies with the sine of the angle of rotation. The diagram shows the basic design.

Information on the device may be obtained from Canadian Patents & Development Ltd, National Research Building, Sussex St, Ottawa, Ontario.



POTENTIOMETER PRINCIPLE is diagramed here. Device is expected to be adaptable to mass production.

Rectifiers hold key to magnetic-amplifier development

Development of magnetic amplifiers for service at 930 F apparently hinges on the availability of rectifiers for operation at that temperature. At least one magnetic-amplifier developmental project has been shelved for lack of suitable 930-F rectifiers, and tests of possible rectifier materials do not hold much immediate promise. But there is hope silicon carbide may eventually solve this problem. Rectifiers made of this material perform well at elevated temperatures (*PE—Feb* 24 '58 p 8); but low-temperature performance needs improvement.

Sound waves to aid metal cladding

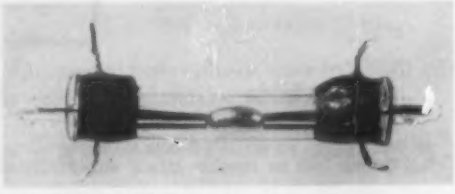
An automatic machine for metal cladding is foreseen by M. J. Whitman of the AEC. Research on ultrasonic roll-bonding, now in progress, says Whitman, may well lead to development of such a machine for cladding flat-plate nuclear fuel elements—a machine requiring only that the stacked components be properly placed on the welding machine table to turn out fully clad parts.

As he points out, ultrasonic roll-bonding offers several advantages over other types of metallurgical bonding for cladding fuel elements. Ultrasonic welds achieve high strength with little external deformation. The welds show excellent corrosion resistance and require a minimum of surface preparation prior to welding.

He emphasizes that development of such a machine is still in its early stages. But an ultrasonic 2-kw roller-seam-type welding array has been assembled on a traversing table bed and used to prepare area-welded surfaces for evaluation. Test procedures have been developed for evaluating the quality of surface bonds. An experimental ultrasonic roll-bonding machine is now being built, and it is expected that simple clad test parts will soon be available for evaluation.

Responsive mercury switch designed in Britain

A mercury switch that provides continuous response to the angle of tilt has been developed by G V Planer Ltd of Middlesex, England. It incorporates integral-film resistor patterns deposited on the inside of the envelope, and carries a resistance rating of 1000 ohms. First models have current ratings of 25 milliamps and, says Planer, output is reproducible to within ± 4 minutes over a range of ± 3 degrees.



BRITISH SWITCH with integral film resistors provides continuous response to angle of tilt.

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Bring your next unusual product to us—we'll welcome the opportunity to serve you regardless of the alloy it might require. Send for the free illustrated booklet, "Quality Control at Standard."

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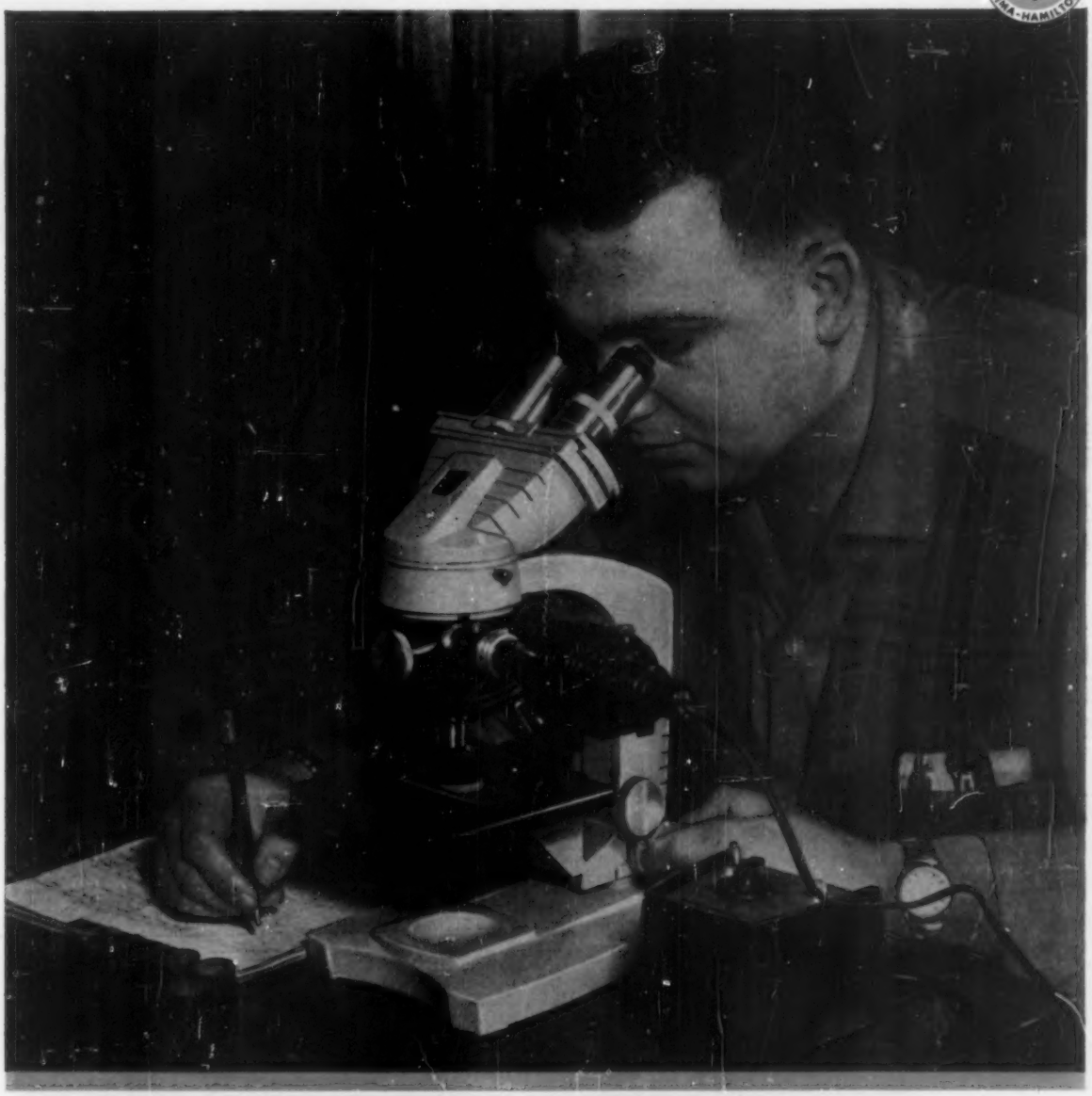

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BURNHAM, PENNSYLVANIA Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

Tungsten alloy claimed strong and stable

A tungsten alloy that can be hot-pressed in graphite dies and shows little component shrinkage, "thereby eliminating the necessity of subsequent extensive surface machining," has been developed and patented by Atomic Energy Commission researchers.

Described as a "high-density quaternary tungsten-base alloy having high strength and good machinability," it consists of about 2% nickel, 3% copper, 5% lead, and the balance (90%) tungsten. It can be formed by standard powder-metallurgy techniques in reusable graphite dies at hot-pressing temperatures in the 2000-2500 F range.

Noble gases solve design problems

In lamps and electron tubes, leak detectors, welding equipment and cryogenic devices, the "noble" gases—helium, neon, argon, krypton, and xenon—are becoming increasingly useful, particularly as supply increases and costs come down.

Neon, well known for its use in lamps, also serves as the current-carrying agent in lightning arrestors that protect electrical instruments; and as an overload protector in motors because it is almost a perfect insulator below its breakdown potential.

Xenon is replacing mercury vapor in thyratrons, because it does not condense at low temperatures, and its low electrical resistance and its optical properties are finding it new applications in high-speed photography. Xenon display and photographic-processing lamps are being developed, too, because they promise high light intensity.

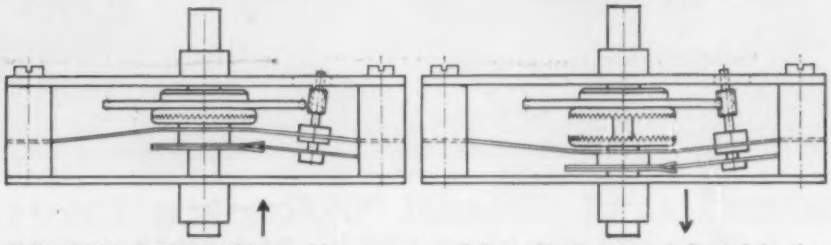
None of these gases is cheap in high-purity form. Argon, neon, and helium are priced at $1.50 per liter in 100-liter cylinders, and range up to $6.50 for single-liter samples. (In welding grade, of course, argon is much cheaper.) Xenon costs $25/liter in quantity, $50 to $60 for small samples. Nevertheless, these prices are far lower than they were even a year ago, and the noble gases are well worth investigating. A good place to start is a booklet just published by Linde (F-1002C), which details properties and gives comparative data.

Drive with coarse-fine gearing devised in West Germany

An in-line shaft drive, with reduction ratios of 1:1 and 1:16 or 1:28, combined in a single element, has been designed by Telefunken of West Germany. It consists basically of friction wheels which grip each other elastically.

Crown wheels with a gear ratio of 1:1 are used for the coarse adjustment; and friction spur gearing, with a ratio of 1:16 or 1:28 for the fine or vernier adjustment.

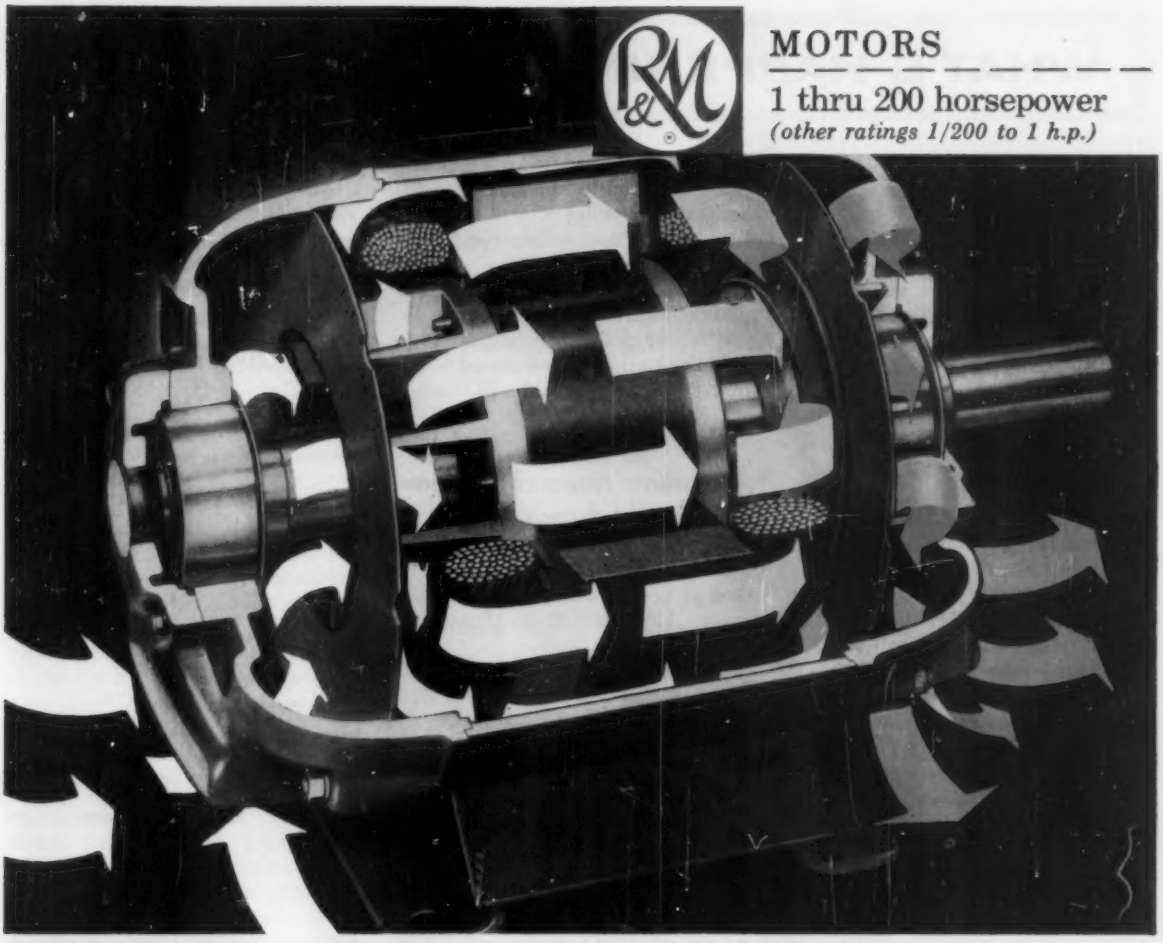
A spring (see diagram) applies pressure to the fine-adjustment pinion, preventing backlash while the coarse adjustment is in use; and uncouples the coarse adjustment when the vernier is brought into play by forward movement of the front shaft. The spring also makes sure that the front shaft is always in gear. —ARG

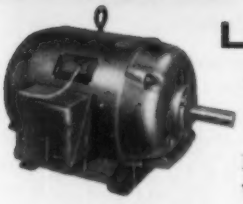


NEW DRIVE MECHANISM combines coarse and fine adjustment as indicated in the diagrams. At right above is a typical application—a radio tuning unit.

MOTORS

1 thru 200 horsepower
(other ratings 1/200 to 1 h.p.)





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R&M motors' long-life insurance also includes these features: Mylar* insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . double width bearings with extra-large grease capacity . . . end heads that offer full height protection . . . removable caps for quick bearing inspection and re-lubrication. For details, write today for Bulletin 520-PRE.

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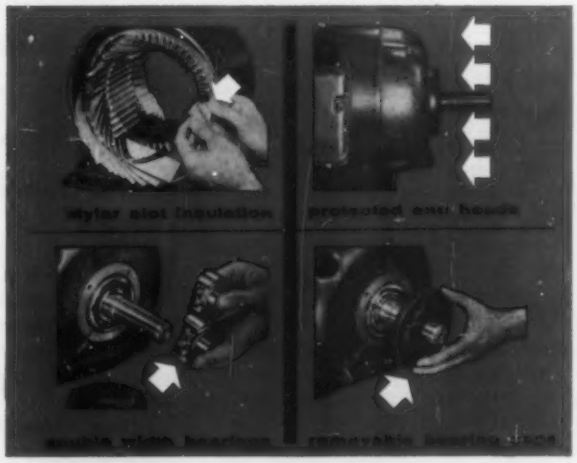

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motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

CIRCLE 9 ON READER SERVICE CARD

WHAT'S HAPPENING IN RESEARCH . . .

"Protective" atmosphere may sap metal strength

Gas adsorption, not corrosion, may be responsible for losses in creep-rupture strength observed when some metals are heated in air. Indeed, corrosion (oxidation) may sometimes be a source of strength. That's the latest word from Naval Research Lab's Metallurgy Div on a long-term study of the effect of environment on creep-rupture properties of metals.

As previously reported, nickel and nickel-base alloys subjected to high temperatures and low stresses were found to be stronger in air than in vacuum; while at low temperatures and high stresses, the reverse is true.

The explanation proposed by NRL researchers: internal oxidation is responsible for the strengthening observed, while gas adsorption on crack surfaces (reducing surface energy and facilitating crack propagation) accounts for the weakening.

Now, tests in nitrogen atmospheres seem to confirm the theory. Rupture life in nitrogen was shorter than in either vacuum or air; yet, say P. Shahinian and M. R. Achter, "The specimens tested in nitrogen were as bright as those exposed to vacuum, indicating little reaction with the environment." But they did show a much greater number of cracks than vacuum-tested specimens.

US pushes organic-semiconductor research

With the Soviets already well launched on studies of organic materials that might serve as semiconductors, US agencies are now sponsoring broad-range studies that include not only resins like the acrylonitrile materials under investigation in the USSR, but also semiorganic polymers.

General Electric, for instance, has an Air Force contract to prepare organic boron and silicon compounds and study the effect of variations in composition on thermal stability and dielectric behavior. And GE also has a study underway of polymeric films that might serve as carriers for semiconductor materials.

Hughes Aircraft is testing indanthrone derivatives, metallic "sandwich-type" compounds, and pyrolitic polymers in an attempt to find materials that combine heat resistance and semiconductive properties.

At least four other companies have studies underway as well but all are still in the preliminary stages. It is unlikely—barring an unexpected breakthrough—that any reports will be available for at least six months.

Australian research promise better cold-drawn steel

Ripples in cold-drawing steel are caused by segregation of aluminum used in deoxidizing the ingot molds, Broken Hill Pty Ltd of Melbourne, Australia reports.

Studies at the company's Central Research Laboratories showed that ripple formation was accompanied by hard ferrite segregate bands or ghost lines, resulting from migration of carbon to these bands on slow cooling of the steel from the austenitic state.

Further tests showed that, when the steel was soaked at 1300 F for a considerable period, a fine constituent with a hardening effect formed within the bands. This was later identified as aluminum nitride.

briefs . . .

Atomic glossary, prepared by British authorities, aims to "meet the needs of laymen" in explaining basic nuclear terms. Although specifically aimed at the British reader, and rather liberally sprinkled with such names as "Trawsfynydd" (site of a North Wales 500-mw nuclear power station), its 500 terms include many of general interest and value (*curie, elastic collision, Wigner energy*, and the like). Copies of the 54-page printed booklet (4¼ x 6¼ in.) may be obtained from Sales Section, British Information Services, 45 Rockefeller Plaza, New York 20. Price: 68¢.

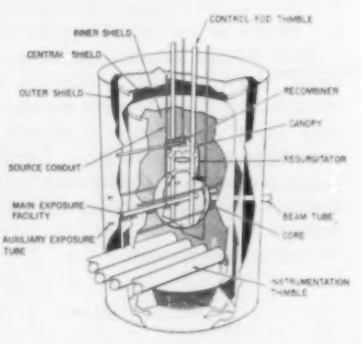
Powdered silver and gold alloys are being studied in West Germany, apparently with the aim of developing materials with greater heat resistance and higher strength. Thus far, the compacted alloys seem to show no characteristic deviations in physical properties from the pure metals. Researchers Ernest Raub and Werner Plate say properties of binary mixtures "can be deduced simply from those of the pure metals on sintering." A report on the studies has appeared in a West German technical publication.

Thin-film resistance thermometers with greater sensitivity than carbon-film resistors, can be made by vapor-depositing a germanium-gallium alloy on heat-resistant glass, U of Chicago researchers believe. Development work is now underway.

Columbium and tantalum tubing in wall sizes down to 0.002 in. (0.062-in. OD) can now be supplied for special jobs by J Bishop & Co, Malvern, Penna. They're not stock sizes; but they can be supplied on order—as can other sizes to 1.5-in. OD by 0.125-in. wall. —ARG

Private company gets reactor-system patent

The little (8 x 8 ft) reactor, diagramed here, is being proudly displayed by Atomics International as "the first complete reactor system to receive a US patent issued to a private company." It's a solution-type unit, designed for research, training and isotope production and, says AI, "it can be transported and installed without adding special facilities."



PRIVATELY PATENTED REACTOR is fueled by enriched uranium in solution, features simple design, has multiple exposure ports for research.

Expert Night Pilot. In certain smaller types of bats, their amazingly precise echolocation enables perfect navigation and hunting of insects. Although the natural sonar system of bats is the smallest known, ounce for ounce and watt for watt it is billions of times more efficient than any sonar equipment that has ever been made by man.

Tiny Control Center. Synchronous at 24,000 r.p.m. in less than five seconds — using overvoltage techniques — this 2 oz., subminiature floated rate gyro assures stable, precise flight control of missiles, special weapons and space vehicles. MPB bearings on critical main shaft help assure accuracy under 150 G's of shock and 30 G's vibration to 2000 cps on any axis.

Man With Miracles. Friction, inertia, and today's ever-shrinking component space provide an exciting challenge to MPB Sales Engineer, Gene Burrichter. Working closely with engineers and scientists he constantly helps solve miniaturization problems throughout industry. MPB Sales Engineers are ready to give you similar assistance.

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FROM WASHINGTON . . .

Design competition scheduled for new cargo plane

The Air Force will begin a design competition this summer on a new long-range, high-speed cargo aircraft. Ten preliminary design proposals by seven companies have already been submitted. **The aim is to develop a plane that could be adapted to commercial air-carrier service, thus improving civil air cargo's competitive position.** Both the Federal Aviation Agency and the Air Transport Assn are working closely with the Air Force on specifications for the new plane to achieve as much civil–military design compatibility as possible.

The Air Force's new budget earmarks $50 million for initial development and engineering costs. Plans call for delivery of first models within four years.

As the situation stands now, designs provide for a turbofan- or turboprop-powered plane with a gross weight of about 315,000 lb, which could be loaded from truck-bed height. Cruising speed is rated at 575 mph (compared to the 325 mph of the Douglas C-133, the most modern cargo plane now operating). **The plane will be designed to function as a global transport—to carry 40,000 lb nonstop over the Atlantic or 20,000 lb over the Pacific—and as a tactical cargo plane that can drop heavy equipment on a battlefield.**

It will be designed also to take off over a 50-ft obstacle in 5000 ft, about half the runway required by most current military cargo planes. Commercially, it's hoped that the new plane will trim direct operating costs about 50% (to 5 cents a ton-mile or so) and user costs to 10 to 12 cents per ton mile (vs current 20 to 30 cents).

Design standards on nuclear weapons divulged

For the first time, the Pentagon is publicly airing some design information about nuclear weapons. **Purpose is to allay public fears that nuclear energy could be accidentally released at the increasing number of military bases which now store or handle warheads.** The disclosure is prompted by the recent furor over the inaccurate reports of nuclear detonations resulting from a fire at a New Jersey missile base.

All nuclear weapons, says the Defense Dept, have "positive design standards" engineered in to prevent accidental nuclear yields and deliberate unauthorized or inadvertent arming, launching, and firing of a nuclear weapon. Included are such measures as basic design; inert storage to bar triggering an explosion; safety switches to allow movement of the weapon even with a power source; concealed or locked safety switches; and dual controls mounted in a series which must be operated independently.

A perfect safety record in 14 years of storing, transporting, inspecting and handling nuclear weapons is claimed. In no case, say officials, has "the nuclear part of a weapon caused or contributed to an accident."

Report methods to compute flat-plate stresses

Office of Technical Services, US Dept of Commerce, Washington, DC, is offering a metallurgical research report explaining two effective methods of calculating stresses and strains in unevenly heated flat plates. Order PB 161087, $2.75.

Also available is a supplementary report (PB 161087, supplement 1, 75¢) which describes a method of determining post-buckling deflections, stresses, and strains in simply supported flat plates.

CIRCLE 13 ON READER SERVICE CARD→

NEW FALK EQUI-POISED* MOTOR MOUNT

for use with the Falk Shaft Mounted Drive

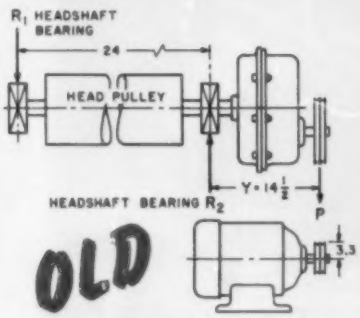
gives unequaled economies plus convenience

HOW A FALK EQUI-POISED MOTOR MOUNT REDUCES BEARING LOADS ON A DRIVEN MACHINE

GIVEN: Motor—15 hp, 1750 rpm, Frame 284U, Weight—320 lb.
Sheave diameters—6.6/9.4
Driven machine—belt conveyor with 24" center distance between headshaft bearings.

NOTE: Weights of 307J24 Shaft Mounted Drive, sheaves, and V-belts are eliminated from calculations because they remain constant; do not affect the comparison.

WITHOUT FALK MOTOR MOUNT



Torque at motor shaft = $\frac{63{,}025 \times 15 \text{ hp}}{1750 \text{ rpm}}$ = 540 lb-in.

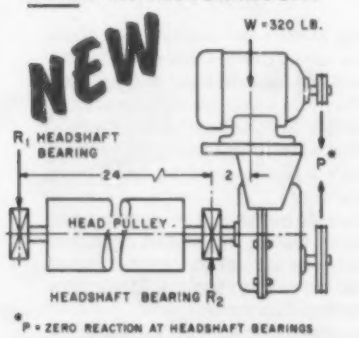
Belt pull (P) = $\frac{540 \text{ lb-in.} \times 1.5 \text{ Load Connection Factor}}{3.3"}$ = 246 lb

$R_2 = \frac{246 \text{ lb} \times (24" + 14.5")}{24"} = 395 \text{ lb}$

$R_1 = \frac{246 \text{ lb} \times 14.5"}{24"} = 149 \text{ lb}$

(Check: 395 lb—149 lb=246 lb)

WITH FALK MOTOR MOUNT



*P = ZERO REACTION AT HEADSHAFT BEARINGS

V-belt pull has zero reaction on headshaft bearings. Therefore—

$R_2 = \frac{320 \text{ lb} \times (24" + 2")}{24"} = 347 \text{ lb}$

$R_1 = \frac{320 \text{ lb} \times 2"}{24"} = 27 \text{ lb}$

(Check: 347 lb—27 lb=320 lb)

Falk's new EQUI-POISED* Motor Mount is a rigid, all-steel weldment, pre-drilled for bolting standard NEMA foot-mounted motor (1/2 to 30 hp) directly to the steel frame of Falk Shaft Mounted, Flange Mounted and Screw Conveyor Drives. With it, motor can be mounted in almost any position around perimeter of reducer.

(*Balancing of forces.)

Substantial Savings for You

It saves engineering time required to design special motor bases and foundations...saves cost of labor and materials required to build special motor foundations...and saves on equipment costs by using a quality stock component. Further, its quick installation and easy maintenance mean added cost savings. The Motor Mount is a space saver, too. Where restricted space is a factor, ability to mount motor in any of several positions is an important convenience...For information on range of sizes, dimensions, etc., contact your Falk Representative or Distributor—or write direct for Bulletin 7100.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

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a good name in industry

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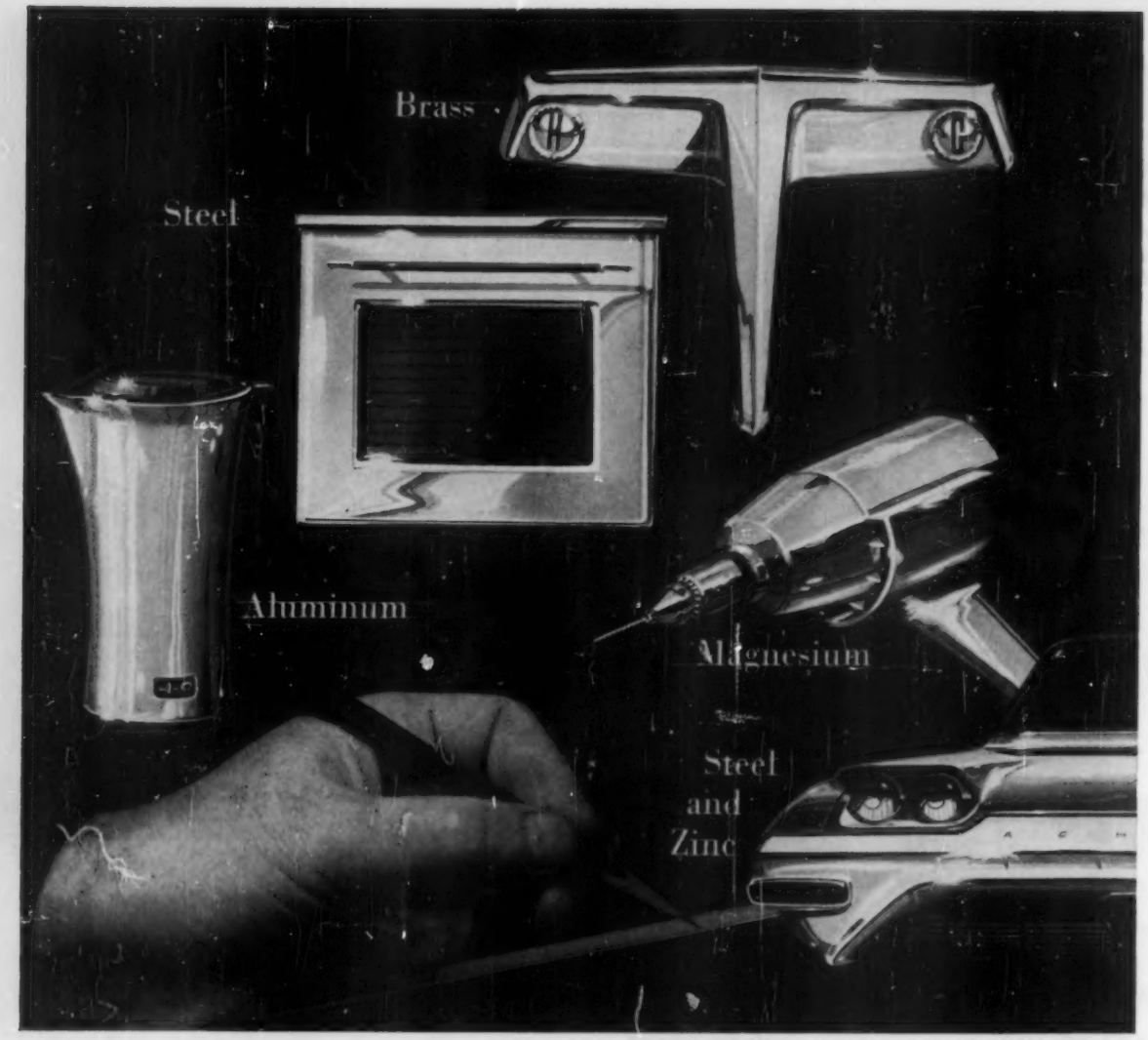

Choose any basis metal you desire and give it

a lustrous, lasting finish of Nickel-Chrome Plating!

Nickel-Chrome Plating provides a practical way to combine the beauty and protection of Nickel and chromium with the special properties of other metals:

- formability of brass
- strength of steel
- extrudability of aluminum
- lightness of magnesium
- conductivity of copper
- design flexibility of zinc-base die castings

Today's adaptable Nickel-Chrome Plating gives you the freedom to use a wide variety of basis materials to achieve the most desirable combination of performance, fabricability *and* practical cost.

Select the basis material that proves most suitable. Nickel-Chrome Plating will give it lustrous, matching beauty with brilliant blue-white color. Beauty with outstanding durability, too.

That's because Nickel-Chrome Plating not only provides shining sales appeal, but also protects basis metals from rust and corrosion. Protects basis materials from nicks and scratches. Makes the lustrous beauty lasting beauty.

So with Nickel in ample supply as far into the future as any man can foresee, there's no better time than now to use Nickel-Chrome Plating to your product's best advantage. Whether you want smoothing action, blue-white brilliance or satin tones—together with long-lasting protection—there's a Nickel coating to fit your requirements.

For information on accelerated corrosion testing of plated coatings, just drop us a card for your copy of "CORROSION TESTING OF ELECTRODEPOSITED COATINGS."

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Nickel makes plating perform better longer

THE ENGINEERING WEEK

Defense Dept Shopping Overseas for Its R & D

WASHINGTON—An Israeli philosopher-mathematician at the Hebrew University is performing research on information-retrieval systems and the mechanical translation of languages for the US Navy. In Belgium, a Brussels professor is studying laminar boundary layers and supersonic flow for the US Air Force. In France, a Univ of Strasbourg physicist is doing research on the magnetic properties of iron-phosphor and iron-boron for the US Army.

These and hundreds of other foreign scientists and engineers have become an important outlet for US government-sponsored research and development. More and more, the government is tapping foreign experts to handle research in a broad range of sciences and technology.

Right now, government-financed R & D overseas runs to about $35 million a year, with the rate of spending steadily on the rise. Almost half the work is done for the military services, the rest for some 10 civilian agencies of the US government.

The government is turning to foreign scientists and engineers because there are many foreign researchers with special knowhow and talents unavailable or in short supply here.

A Navy scientist who administers foreign R & D projects points up a related factor: "In general, Europeans are better thinkers than we are. We are greatly interested in the small individual efforts of people who are doing creative thinking in a field connected to our requirements."

A second reason for foreign R & D contracting is tied to US objectives in building up scientific and industrial facilities in countries allied to us. American R & D contracts are essentially a subsidy in certain cases. As one Defense Dept official puts it candidly: "We want to get some countries off our back so that they can become prepared to supply themselves with military hardware."

MORE BASIC THAN APPLIED

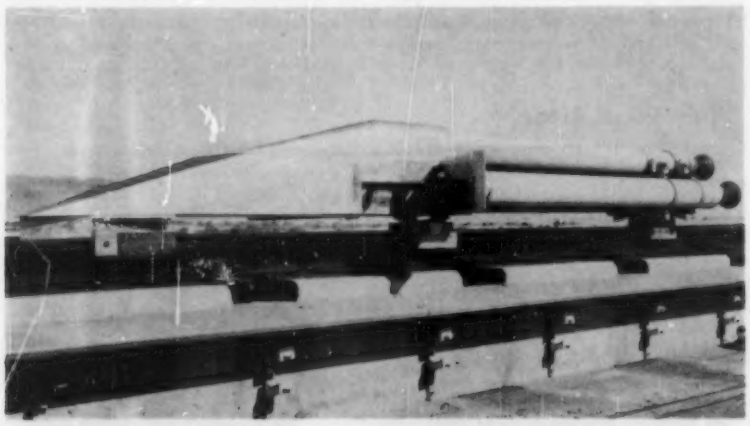
But the bulk of the R & D work performed for this country overseas is of a fundamental research nature rather than in fields leading to development of hardware. "The US is hardware-oriented," says the Navy scientist. "It is unusual to find a company overseas that can do as good a job for us as a domestic firm."

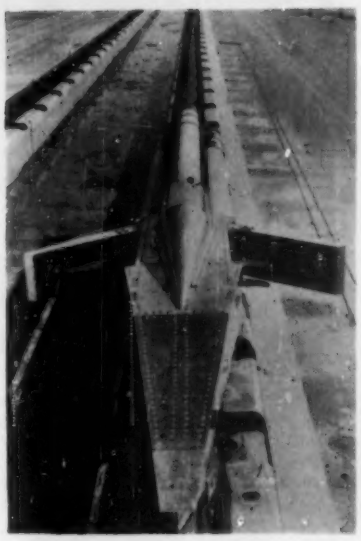
There is another factor which keeps practically all foreign R & D contractors out of the military-hardware field: Pentagon restrictions on military procurement from foreign sources.

Still, in extraordinary cases, the military does turn to foreigners for military-hardware development. One of the most notable cases is the Companie Generale de Telegraphe Sans Fils of Paris which is developing radar-jamming tubes for the Air Force and analog and digital storage tubes for the Navy.

The nonmilitary agencies of our government which support foreign research include the Agricultural Dept, Commerce Dept, the National Institutes of Health, Interior Dept, Atomic Energy Commission, State Dept. Federal Aviation Agency, US Information Agency; National Science Foundation, and National Aeronautics & Space Administration. NASA's interest is centered on its worldwide net of tracking stations.

The civilian agencies will spend close to $20 million this year, as much as 30% more next year. Just two





Fins Stop This Rocket Sled Fast

This monorail rocket-propelled research sled, built by Northrop Corp, was braked to a safe stop from 2688 mph in less than three-fourths of the 35,000-ft captive-missile test track. The quick stop was accomplished by unique braking fins fitted into the sled's pointed nose. Inertia keeps them closed until the instant of rocket burnout. Then the initial deceleration causes the fins to open about 2 in. after which they are fanned out to full braking capacity by the wind blast, right photo. Sled measuring 21 in. high, 16 ft long will be used to test components of inertial guidance systems for the Air Force.

years ago, the rate of nonmilitary spending overseas for R & D ran to only about $10 million.

A stimulus for the increase in foreign R & D was a recent congressional directive that foreign currencies obtained from the sale of surplus farm commodities can be spent on scientific research.

The military services are so heavily involved in overseas R & D work that the three services have set up European offices to administer the contracts. Last April, the Army also opened a research administration office in Zama, Japan to handle the growing volume of contracts in the Far East. There are predominantly in the biological and medical sciences.

The Air Force has the biggest R & D programs of the three services. In 1953, the Air Research and Development Command opened an office in Brussels, Belgium to handle the program. Since then the program has expanded from a volume of $250,000 to $10 million, covering 400 individual projects in 16 countries.

The Air Force sponsors work in just about every scientific discipline—from metallurgy and electronics to geophysics and the bio-sciences.

The Army has some 140 overseas R & D projects underway with a total budget of $1.8 million. Since 1956, it has had a staff in Frankfurt, Germany to handle the program. The Army stresses work in chemistry, materials, geophysics, and medicine.

The Navy manages its overseas work from London. It has 34 projects underway in Western Europe and Israel, valued at $1.2 million, with activity in just about the same scientific fields as the other two services. ■

Nuclear-fuel Elements Made Better, Less Costly

DETROIT—Working on a grant from the Atomic Energy Commission, Electric Autolite Co has developed experimental extruded, ceramic, nuclear-fuel elements that show superior performance and significant cost savings.

Present uranium or thorium oxide elements are pressings, and a full charge costs several million dollars. The experimental Autolite extrusions already have been tested to operate at above 95% density. Estimates indicate a cost saving of about 40% per inch of charge. ■

Chevy Casts Aluminum by Low-pressure Method

MASSENA, NY—Low-pressure, permanent-mold method of casting aluminum, previously used only in Europe, is the process by which Chevrolet builds most of the aluminum parts for its Corvair as well as some of its "regular size" car models.

The process is not yet available commercially in this country—Chevrolet has the only US installation. However, its success in Europe and the fact that it has been adopted by a large division of the General Motors family gives the process sufficient impetus to interest commercial foundries, and thus make the process available to industry generally.

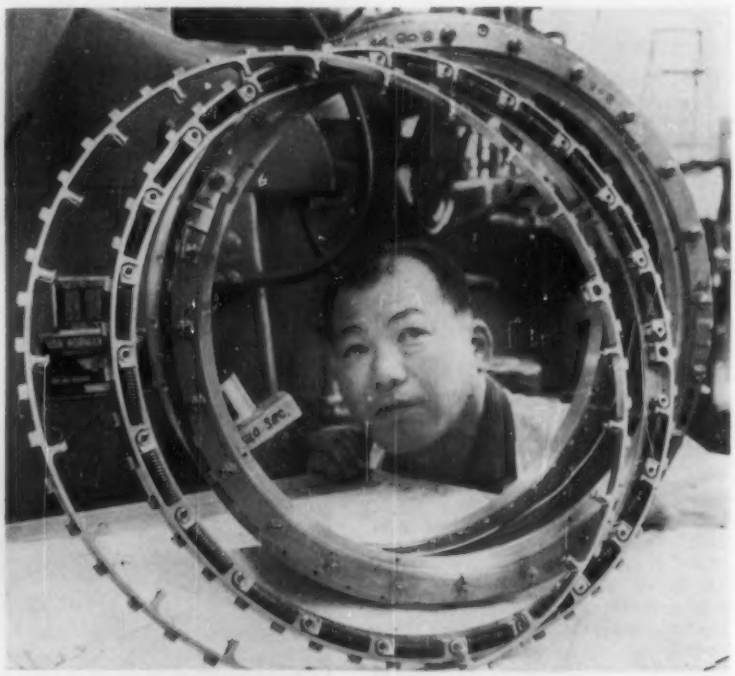
TOOLING COSTS DOWN

Main advantage of the process is its relatively low tooling cost—approximately one-tenth that of die casting—and reliability of the parts produced, especially their soundness. Production rates per operator compare with those of the die-casting process. But the die-casting machine operator works on only one machine and one mold at a time; while in the low-pressure casting process, the operator governs three machines simultaneously, permitting production to be divided among three different parts —one per machine.

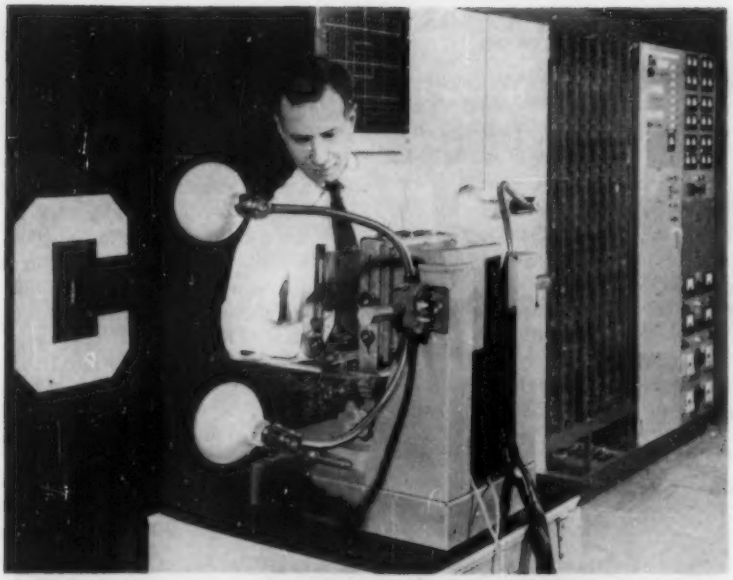
Actually, the process is adapted for production quantities that would make the tooling for die casting uneconomical, yet make other processes too slow to meet production rates.

A further advantage of the process is that much of the metal is used for producing the part itself, with only a minimum going into gates and risers. In this, too, the process is similar to die casting. For instance, approximately 95% of the metal goes into parts, compared with about 60% in sand casting. —Felix Giordano

With These Rings



Locking rings for the Argo D-8 Journeyman, a 4-stage research rocket, are inspected by an Aerolab Development Co engineer. The rocket is planned as a booster for a 125-lb General Electric Co instrumentation payload—equipment for studying Van Allen radiation belts surrounding the earth. With split-second accuracy, these locking rings will separate the 4 stages of the D-8's flight. Maximum altitude is 1200 mi along a 1700-mile flight path. Flight will be made next fall from Pt. Arguello, Calif, a site on the Pacific Missile Range.



MARK I PERCEPTRON designed and constructed by Cornell Aeronautical Laboratory is here being adjusted during a letter-recognition training sequence. Present unit is intended for research purposes; future perceptrons could be constructed to differentiate between patterns or objects now requiring human operators. In some experiments the letter-recognition problem has been complicated by adding letters of a different type face and the machine has been correct 79% of the time.

Learning Machines Are Getting Smarter

BUFFALO—The thinking machine—a favorite science-fiction device—may be closer than is realized if the Cornell Aeronautical Laboratory Mark I perceptron unit is any indication This laboratory model of what eventually may become a family of efficient pattern-recognizing machines ran through the alphabet without error. Its developer, Dr Frank Rosenblatt of the CAL staff noted that for the 26-letter recognition test the machine performed without error after 15 exposures to each letter.

As reported in PE May 4 '59, the principle of perceptron may take over the tedious and dangerous tasks of space exploration, automatic navigation, and recognition systems of every variety. CAL and its sponsors, the Office of Naval Research with the assistance of the Rome Development Center of the Air Research and Development Command, are more conservative, saying only that "it is possible that in the future a perceptron of much greater capacity could be used to read print of various type faces and recognize spoken words. Similar machines might also be used to extract salient features of photographic information."

The Mark I perceptron, says Dr Rosenblatt, has been patterned after the current concepts of a biological nerve system, including number of neurons, logic of connections, reliability, random variation in "wiring diagram," and type of signals used.

HOW IT WORKS

The Mark I uses conventional electromechanical devices. Machine's sensory units—which translate the stimulus pattern into a discrete set of electrical signals—consists of a 20 x 20 square array of photo-resistive cells mounted in a phenolic base plate. This plate is positioned in the film plane of a view camera.

The stimuli are white-on-black letters or other patterns held in front of the camera. Each photo cell that receives sufficient light from a stimulus actuates a transistor-driven relay, which supplies "excitatory" and "inhibitory" signals.

Signals are received by the machine's association units which are also transistor-driven relay circuits. These "A-units" receive input signals over a random wiring network from the sensory units. The A-units—Mark I has 512 of them—have a fixed threshold and when the input from the sensory units exceeds this threshold the unit becomes active. Active A-units, in turn, supply output signals to the machine's response units. The amplitude of these signals is controlled by a memory device in each association unit.

THE MACHINE TALKS BACK

The machine's response units are two-stage devices consisting of a dc amplifier driving a relay. The response unit's input is the sum of the signals from the A-units to which it is connected. The response unit gives a visual indication of its state and transmits a reinforced signal to the A-units, which are active. This reinforcement signal is stored by the memory devices in A-units to change the amplitude of their output.

The Mark I has eight response units allowing for 256 possible responses. All may be used when discrimination between several stimuli is desired. A single response unit is used when a simple either-or discrimination task is performed. However, it is anticipated that many more association units would be required to use fully all of the possible responses.

The ability to generalize on its experience is an important feature of the perceptron. After exposure to a limited sample of forms from a given class, the perceptron is able to recognize other members of that class although it has never seen their particular image before. For example, having been exposed to a number of E's it can recognize an E similar but not identical to those it saw previously.

This ability to generalize from experience is one of several features which sets it apart from most other pattern-recognition devices. In addition, perceptrons are general-purpose machines, and each can be trained to perform any one of a wide variety of pattern-recognition tasks. Another unique point is that the design is based on a small number of statistical parameters and some general logical constraints within which the actual connections can be drawn from a table of random numbers. ■

Bit by Bit—More Reliable Computer Communication

SAN JOSE, CALIF—Another step toward more reliable communication between remotely located computers has been taken by IBM with development of extra checking bits which detect, then correct errors or bursts of errors. Transmission errors, caused mainly by static and short interruptions, lessen reliability and slow the communication rate.

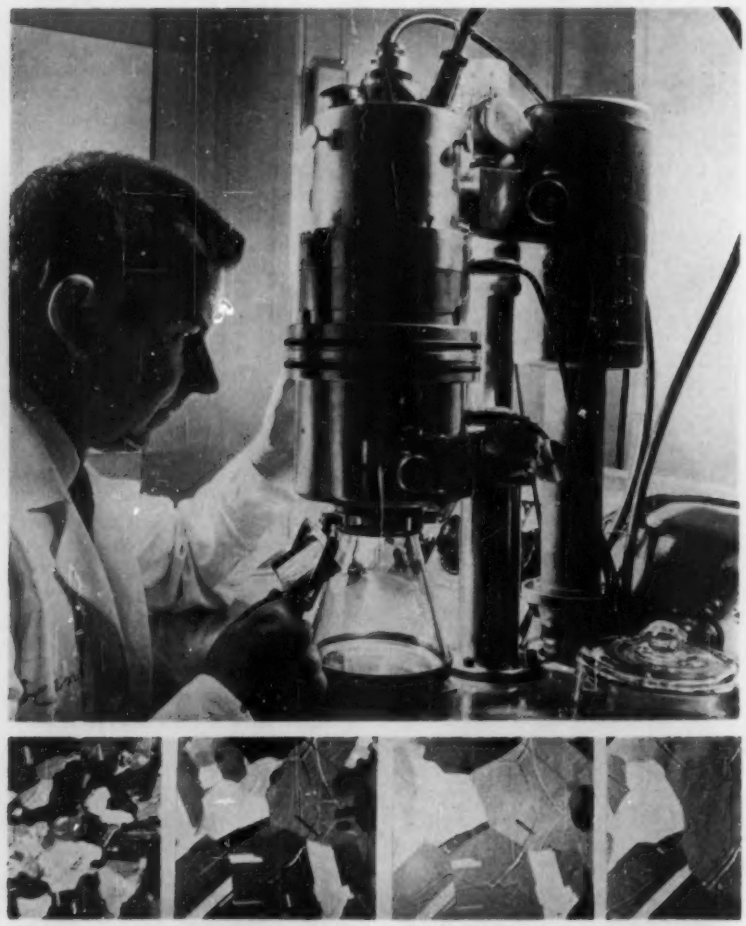
The checking bits (or "sleuths") are placed at the end of each block of transmitted bits of information. This code, differing considerably from previously developed codes, drastically reduces the number of required checking bits. In addition, its circuitry is simple and inexpensive.

During transmission, a head count of bits is simultaneously underway. If any bits are lost, the checking bits report the errors, locate and identify them and then make the necessary corrections. The original message and the correction bits arrive at the receiver at the same time.

Most transmission errors result because static blots out the signal. Noise spikes sometimes are as much as 100 times stronger than the received signal. Since static is normally of short duration, it does not disturb the human ear during voice conversations. The speaker can "fill in the gaps" so the dialogue remains meaningful. But when bits of computer information are lost, the message may be meaningless.

The same type of checking system can also be used to increase reliability of computers and magnetic-recording systems. The new development, which may be incorporated into IBM's Tele-processing systems, is based on the theory of dependent-error and multiple-error corrections. ■

Microscope Views Metals in Action



This new thermionic-emission electron microscope, developed by General Motors Research Lab's Physics Dept, observes behavior of metals at high temperatures. Metal samples magnified up to 3000 times can be seen continuously and "live" on the microscope's viewing screen as they are heated in a built-in furnace. For example, insert along bottom of photo shows microstructural changes occurring in steel sample (SAE 1080) at temperatures ranging from 1800 F, left, to 1950 F, right.

US Adds Twins To Satellite Family

CAPE CANAVERAL—Two shiny new US satellites have been hurled into orbit by a single rocket, scoring a spectacular first for our missilemen.

The doubleheader rocket that turned the trick was a two-stage Thor-Able-Star, an Air Force vehicle making only its second flight. It rose smoothly from its searchlight-illuminated pad and headed southeast.

The second stage fired for about four minutes, shut off and coasted for 20 min, then reignited for 13 sec to kick the satellites into orbit.

The two new moonlets are a Transit II-A, which will aid navigation, and a basketball-size aluminum sphere crammed with instruments to measure solar radiation. Transit II-A, a 26-in. ball, weighs 225 lb. The smaller package, called a "piggy back" satellite because it was clamped to the larger sphere until they were sprung apart in orbit, weighs 42 lb.

Transit II-A is primarily intended to aid navigation of Polaris-missile submarines; but it will also help other surface craft and airplanes.

In Washington it was reported that Pioneer V orbiting the sun has passed the 20 million-mi broadcasting range limit expected by its designers and still is sending signals back to earth.

The 26-in.-dia space probe, launched March 11, sent back a clear signal heard for two or three minutes.

In recent weeks signals from the 5-watt transmitter frequently have been faint and unreadable. However, the background static cleared enough yesterday for good reception. ■

Zirconium Finds Friends Among Corrosion Experts

NEW YORK—Despite its initial high cost, zirconium can be an economical way to solve design problems caused by corrosion. That's the opinion of a panel of experts from New York Univ, the Bureau of Mines and Carborundum Co—who met recently at NYU in a seminar sponsored by Carborundum Co.

This metal, first developed for atomic reactors, is finding wider application because it resists acids and alkalis. Zirconium alloys also provide a defense against hot water and steam. For such applications, an alloy having 1½% tin—Carborundum's 30 series—has been made available by the Atomic Energy Commission. These alloys with less than 0.02% hafnium are said to resist water corrosion up to 600 F and steam to 650 F.

Carborundum officials decline to estimate zirconium prices. So far, they say, the market is not large enough for standardized sheet or castings. Each application is a special case. But high initial cost can be offset by improved service life. Dr Donald Spink of Carborundum cited one example: a cast-zirconium unloading plow for a centrifuge cost $485. Its counterpart of Hastelloy C cost $353. Zirconium paid off here, he said, because the plow has been in operation about 2 years; the Hastelloy plow became severely corroded in a month.

Dr Earl T. Hayes of the US Bureau of Mines emphasized that zirconium is not a refractory metal. Its melting point is about 3350 F. Ultimate tensile strength for Carborundum's series-10 metals—a commercial grade with 2% hafnium—is rated at 65,000 psi. Strength drops to 30,000 psi at 600 F and to 15,000 psi at 1000 F.

The panel agreed engineers will have to develop new design approaches to take fullest advantage of the metal. Often zirconium works best with other metals as a shield for corrosive surfaces.

This metal does not readily weld to other materials such as stainless steel. But zirconium-to-zirconium welds are easily made if the work in carried out in an inert atmosphere. Machining and grinding are feasible with certain precautions such as slow speeds, heavy feeds and application of a cooling lubricant. ■

New Process Color Anodizes Aluminum Diecastings

HAMILTON, OHIO—Aluminum diecastings that can be color anodized are being made by Hamilton Die Cast Inc. Colors are clean and controlled and can be applied over three types of basic finishes—scratched satin, polished satin, and semigloss matte.

Called Hamiloy, it has tensile and yield strength equal to the standard alloys used in the die-casting industry; and has 5 to 7% elongation as compared to 2% in such conventional alloys as 380 and 13. Until now, only limited sizes and shapes of aluminum diecastings could be color anodized. With Hamiloy, many more varieties can be color processed to be as strong, but not as brittle, as present non-anodizable alloys. Hamilton reports that numerous design changes in its vacuum die-casting machine are responsible for successful development of Hamiloy, but declined to discuss these changes. ■

Junior-size Jetliner

First production model of the 550-mph Lockheed Jetstar is rolled out for a checkup. All the electronics, pressurization, air conditioning and other equipment of a huge modern jet transport have been packed inside this 8-passenger craft. Though deliveries to business and government customers won't begin until next year, Jetstar will be flown for the first time this month.

Tunnel Diode Monitors Light Intensity

Light intensity of this 200 w bulb is controlled by a tunnel diode in novel static circuit, described for the first time at recent AIEE (American Institute of Electrical Engineers) conference in Atlantic City. Circuit's inventor, R. E. Morgan, scientist at GE Co's General Engineering Laboratories, predicts it will have many other applications — including speed control of fractional and integral hp squirrel-cage induction motors. Principle of operation: power element in circuit is a silicon controlled rectifier; it is triggered and timed by tunnel diode, which oscillates at any selected frequency, controlled by small saturable reactor. See a coming issue for staff report on this development.

POINTS OF VIEW

THE QUESTION:

Which serves industry best—

Dr A M Zarem
Former asst director
Stamford Research Institute
President
Electro Optical Systems
Pasadena, Calif

"Whether a research organization is profit-making or not . . .

need not dominate its management policy to the extent of influencing the caliber of research performed there. However, it is clear that, in our system, based upon incentives, people who must scratch to show they are best will be sharpened to the finest point of competitive skills. These may be more frequently found in a profit-type research organization, whose very existence must depend, not only on talents to perform the tasks awarded it, but also on its abilities to detect and conquer new fields of technology for eventual utilization in military, space and industry.

"Such an approach to research does not necessarily deprive a profit-making organization of the type of atmosphere consistent with good research activities. In fact, the result is to the contrary. As curiosity is the key element in any successful research, it follows that the outstanding research scientist will find a more dynamic market for his talents in an environment that is constantly attacking the forward areas of technology. Possibly the real question in profit versus nonprofit research is 'How does one put together the most significant kind of productive effort for development of advanced research capabilities to their fullest?' The mechanics by which this is done are trivial, so long as one remembers that the final goal is an unrestricted approach to the problems at hand.

"One should realize, however, that there is a very definite place for the nonprofit organization, established by grants, whether they be from the government or other sources. There are problems that have to be solved by large entities, including governments, which require completely unbiased and unprejudiced disciplines. In these cases, it would appear that the only kind of organization that can do this job is one whose reputation is 'purer than Caesar's wife.' The American economy needs such organizations. But they have not yet begun to attack all the problems they should."

"It is extremely difficult . . .

to comment on the relative advantages of nonprofit and profit-making organizations for industrial research. Research—even industrial research—is so much a matter of individual effort and the specific abilities of the persons doing the work that the type of organization is relatively unimportant. I am very well aware of the splendid work being done by many research laboratories in the country, which are organized on a profit-motivated and, I hope, profitable basis. On the other hand, there are certain fields of work in which nonprofit organizations, such as Battelle Institute, some universities, and other research organizations are preeminent.

"The merit of these organizations resides in their specific abilities which, in the final analysis, are dependent upon the specific abilities of the persons in the organizations conducting the research. Certainly, the absence of a profit motivation on the part of an organization is considered by the research scientists who seek association with the organization. Men who are interested in the advancement of science quite naturally are attracted to organizations which have this as their purpose, rather than the purpose of making a profit through science."

B D Thomas
President
Battelle Memorial Institute
Columbus, Ohio

nonprofit or profit-making research groups?

Cyrus Adler
President
Manhattan Physical Research Group Inc
New York City

"There are no strictly 'nonprofit' . . .
technical research organizations. Profit need not consist of money but may be in the form of accumulated knowledge, prestige, the development of a research facility or the training of personnel. It would be more appropriate to divide research groups into taxpaying and tax-free groups. Most tax-free educational institutions use part-time teachers and student personnel on their research programs. In effect, students working for minimal wages subsidize the research. After many years of low-paid technical work the students may be paid off to a degree, with a degree.

"Many tax-free organizations compete for industrial-research profit. Schools usually do so at the expense of their students; especially their undergraduates. Teachers are hired—though they cannot, or do not desire to teach—because they can attract research contracts. And professors must 'publish or perish.' If 'tax-free' research institutes stuck to basic research, no one would complain. But a recent survey published by the NSF showed that the tax-free research institutes devoted more than 90% of their activities to industrial research—in competition with taxpaying research groups.

"Tax-free institutes should publish the results of their research for the benefit of the public, which allows them tax advantages. But usually they hold the results of their findings confidential until their industrial sponsor can reap an advantage. Despite the usually lower prices charged by tax-free groups, taxpaying firms can compete with them, because the latter are more product-oriented and cost-conscious. It does not seem to be in best interests of the country for tax-free organizations, often camouflaged with university names, to engage heavily in industrial research."

"Economy and practical results . . .
are only two of the major advantages afforded clients by the profit-making organizations. An independent research laboratory might appropriately be described as 'a profit-making organization dedicated to obtaining research results that will make profits for its clients.'

"The profit-making (taxpaying) research groups are practical, and economically aware of the necessity of providing optimum industrial research value per available research dollar. This they must do if they are to retain clients. On the other hand, the so-called nonprofit (tax-favored) researchers, whether they be educational or research institutes, by their self-proclaimed designation, are not supposed to make a profit. Could this also mean their research is conducted uneconomically? The successful profit-making research organizations are directed by scientists who also are business executives. They are accountable for every industrial research dollar with which they are entrusted. They know how to produce optimum research results upon a minimum research budget.

"Closely allied to these aspects of economically conducted R & D are favorable and practical results. The profit-making technical teams are well versed in different branches of science and technology. They generally have substantial backgrounds of practical experience. Thus, they are geared to produce practical answers. Industrial research findings must be practical to be of value. Many a theoretically sound process has failed because it was uneconomical. Likewise, theoretically excellent formulations (products) have either never reached the store shelf or failed because the consumer would not buy. The profit-making industrial researchers are ever conscious of this."

Dr Roger W Truesdail
President
Truesdail Laboratories Inc
Los Angeles

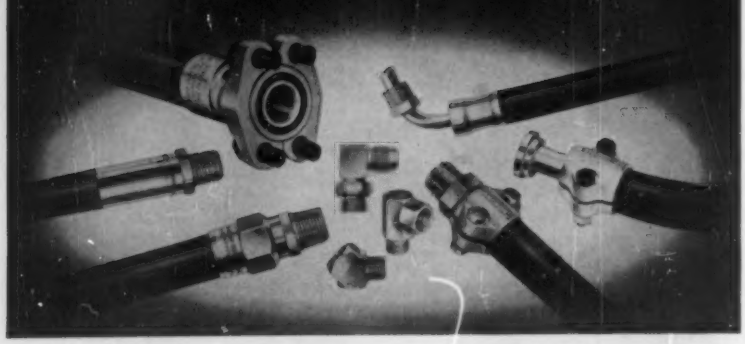
ANCHOR...THE PLEDGE OF PERFORMANCE

IN HYDRAULIC TRANSMISSION LINES

Failure in a fluid power transmission line is usually costly, with expensive equipment down, production delays and idle manpower until repairs can be made.

To hold such breakdowns to a minimum, Anchor has not only established rigid quality standards to which all Anchor Hydraulic Hose Assemblies must conform, but makes frequent tests and inspections of materials and workmanship to ensure conformity to these high standards.

Because of this, the Anchor emblem on any piece of hydraulic equipment is a real "pledge of performance" and service.



Andy Anchor says:

Send for catalog describing the complete Anchor line.

ANCHOR HOSE ASSEMBLIES with ANCHOR Pressed-On Couplings are available for high, medium and low pressure service with maximum working pressures ranging from 12,500 PSI for 3/16" I.D. 6 Ply Super Spiral Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR REUSABLE COUPLINGS — Regular or Clamp Type, are available for emergency repair and year-to-year superior performance for high, medium and low pressure service ranging from 5000 PSI for ¼" I.D. 2-Wire Braid Hose to 100 PSI for 2" I.D. Spiral Wire Suction Hose.

ANCHOR 4-BOLT SPLIT-FLANGE "O" RING HEAD COUPLINGS are available in a wide range of sizes for high, medium and lower pressure applications.

ANCHOR ADAPTER UNIONS, PIPE FITTINGS, SAE BOSS TYPE FITTINGS A complete line of Pipe and Tube Fittings, Adapter Unions and SAE Boss Type Fittings are offered in a variety of styles and sizes to satisfy the requirements of any installation.

ANCHOR COUPLING CO. INC.

346 North Fourth Street, Libertyville, Illinois

Branch Plants: Dallas, Tex., Plymouth, Mich.

READER TO EDITOR

Missile Aborts Not Our Fault

To the Editor:

It's a mistake. On page 16 of your May 16 issue you show pictures purporting to be "some causes of missile aborts." Two of our 600-amp contactors are shown in the top right-hand corner, and we hasten to point out that either you were given, or used, the wrong picture. The Martin Co has been very happy with the performance of our several units on the Titan. There have been no failures whatsoever, for the units are designed to meet the severe vibration requirements that you mention. We should also point out that the picture of a burned relay, which you show in the lower right-hand corner, is that of another manufacture—not ours.

Our contactors are between battery and bus, and not in the "destruct package" as your picture implies. We are sensitive about this whole thing for two reasons. In the first place, we heard from our field representatives that one competitor was circulating the story that it was our unit that caused this failure of the Titan. In the second place, any aircraft engineer who ever used one of our thousand different relays, would recognize your picture as a Hartman component. Contactors of this type have been used in the Industry for 15 years. It is the man who would recognize these devices that we count on for our new business, and it could really hurt if he ever saw your article.

—L F Hartman
The Hartman Electrical Mfg Co
Mansfield, Ohio

• It was not Product Engineering's intention to show directly or indirectly that any manufacturer's product was at fault. The picture used merely represents a failure area and the accompanying text indicates Martin's method of handling it. —Ed

Correcting the Record

To the Editor:

We were rather surprised when several of our friends called to tell us that we were part of the cover of your May 2 issue of Product Engineering. However, both Mr. Parker and I, who had the indescribable thrill of seeing our Iceberg Detector perform a greatly needed function aboard SARGO during her mid-winter Arctic cruise, were surprised to know that we had changed our job affiliation. To set the record straight, we are engineers at the U. S. Navy Electronics Laboratory, San Diego, California; not the Naval Research Laboratory. During our cruise we were under the ice 31 days, 4 hours; traveled 6003 miles under ice; surfaced 20 times; reached the North Pole at 0934, 9 February 1960; traveled 2002 miles in shallow water under ice; observed a minimum air temperature of —40° F.

—A H Roshon
Head, High Resolution Sonar Branch
U. S. Navy Electronics Laboratory
San Diego

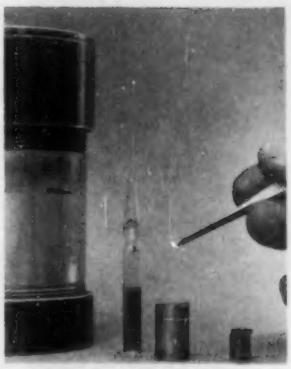
FOR YOUR INFORMATION (personal)

Atomic age safeguard: wedding bands

There's safety in marriage in the atomic age –or will be, if studies now underway at the AEC Los Alamos Lab pan out. And "pan out" is a good expression for it. Says Payne Harris of LASL: "For a long time we've been looking for something that people normally have with them that would give an index of radiation exposure."

It looks as though gold wedding rings may be the answer. When bombarded with thermal neutrons, gold gives off gamma rays that can be detected with practically any kind of counter–even if the exposure has been very small. Dental plates and fillings might serve the same purpose–and some coins, especially quarters and copper pennies –might do the job, too.

LASL is also developing regular dosimeters tiny enough (lower photo) to be built into buttons or belt buckles.



RINGS AND COINS (above) may serve as radiation exposure indicators to ensure proper medical care in case of attack. Lower photo shows progress in miniaturization of dosimeters. First model was 5-in. giant in can at left. The tiny one held in tweezers can be built into buttons or belt buckles. Its container is the small cylinder at far right.

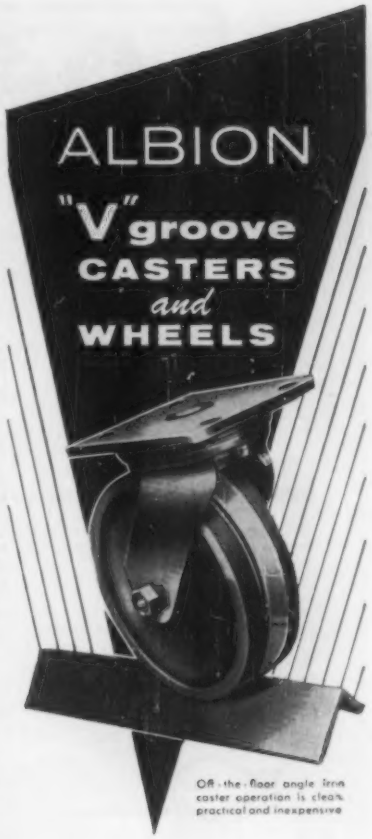
Safe key-ping

A safe for keys is the latest gadget to delight the motorist, boatsman, or just the careful householder. The idea: you can keep the key right at the door or strong box; open the safe by combination whenever you want to get in. No danger of losing the key, says Malloy Co, PO Box 3267, North Sacramento, Calif; and, if you're away, you can telephone the combination to a friend if you want him to have the key to get something for you. Key-Safe price is $6.

Less beefing about steaks

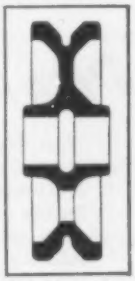
With the aid of pre-fed antibiotics (to prevent spoilage) and new heating equipment (to hold temperature at 110 F), it's now possible to move steaks almost directly from the hoof to the hot plate–and they have the prime aged taste.

A process worked out at the American Meat Institute Foundation substitutes the elevated-temperature treatment for the traditional long-term cold storage (35 F) aging; and, says AMIF, produces in 24 hr a product comparable to that which previously required 2 to 3 weeks. All that's necessary is to inject the antibiotic (in very tiny amounts) before slaughter, and then let the meat enzymes go to work. The process has not yet received USDA approval; but it could mean a major equipment change for the meat industry. –ARG



● Albion heavy duty V-groove casters offer greater utilization of floor space – easier, safer, more economical handling of heavy loads, protect flooring and speed production line operations.

Designed for use on inverted angle track – for *any* service requiring complete control of the truck or conveyor unit, Albion V-groove *self-cleaning* casters are also ideal for on-the-floor operation. And . . . only Albion offers a *complete* range of wheel sizes from 4", 5", 6", 8" and 10" diameters in full swivel or rigid models with a choice of wheel bearing types, capacities from 500 to 15,000 pounds and special features to suit your needs. Remember . . . specify Albion casters and wheels for guaranteed quality and economy.



Typical cross section shows the broad V-groove and load equalizing relief groove.

Contact your nearest Albion representative or write direct

ALBION INDUSTRIES, INC.
ALBION, MICHIGAN

PRODUCT INFORMATION

NEW LAND-RIDING SEAL (Pressed) and SENTRI-SEAL

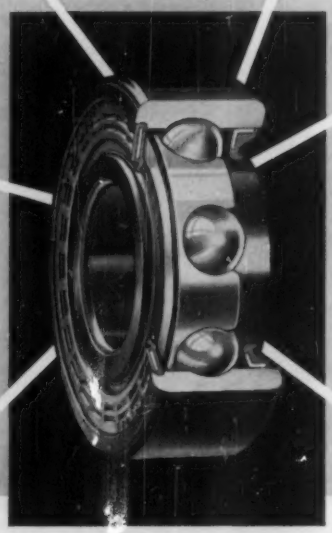
This exclusive seal combination is available in N/D's new heavy-duty conveyor ball bearings. Land-Riding seals, especially resistant to moist contaminant penetration, are available separately in N/D's bearings for hay rake tine bar, plow, hiller and coulter applications. Tandem seal arrangements are also available.

NEW SENTRI-SEAL

N/D's most versatile seal . . . available in most single row, non-loading groove and small double row N/D ball bearings. N/D Sentri-Seals are recommended for applications with moderate to severe contaminant conditions as found in light duty discs, idler pulleys, cam followers, implement wheels, adapter bearings and similar applications.

NEW LAND-RIDING SEAL (Crimped)

N/D's newest seal design. Efficient single lip, low-torque seal protects against moist or dry contaminants. Retains bearing lubricant-for-life. Recommended for farm implement discs, idler pulleys, wheels and similar applications. Available also with metal trash guards to protect seal against mechanical damage from trash windings.



NEW DOUBLE "O" SEAL

N/D's most original seal design, used in fan and water pump bearings where water seepage is prime source of bearing contamination. Synthetic rubber seal rides smooth shaft O.D., offers reliable low-torque sealing and eliminates relubrication.

NEW TRIPLE LIP SEAL

N/D's most rugged seal . . . used where moist and dry contaminant conditions are most severe. Seal eliminates relubrication maintenance. It's available in N/D square and round bore ball bearings with either spherical or cylindrical O.D.'s.

N/D Introduces 5 New Integral Ball Bearing Seals!

Now, New Departure offers a versatile line of new integral seals for N/D precision ball bearings. Each N/D seal is engineered to retain bearing lubricant for life . . . and offer maintenance-free service. These seals are designed to give manufacturers a broad selection to choose from for a specific application.

Modern design N/D seals are made of synthetic rubber with supporting steel components for precise control of sealing lip flexibility and torque. Whatever the application, you'll find an N/D integral seal and ball bearing to fit it. All seals are available in popular sizes of New Departure ball bearings.

Write today for N/D's Integral Seal Bulletin. For detailed information, contact the N/D Sales Engineer in your area. New Departure Division, General Motors Corporation, Bristol, Connecticut.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

PRODUCT ENGINEERING HORIZONS

July 4, 1960

DEMOCRACY

"Our constitution is named a democracy, because it is in the hands not of the few but of the many. But our laws secure equal justice for all in their private disputes, and our public opinion welcomes and honors talent in every branch of achievement. . . .

"We are obedient to whomsoever is set in authority, and so to the laws which offer protection to the oppressed. Yet ours is no work-a-day city only. No other provides so many recreations for the spirit, and beauty in our public buildings to cheer the heart and delight the eye day by day. Moreover, the city is so large and powerful that all the wealth of the world flows in to her, so that our own products seem no more homelike to us than the fruits of the labors of other nations.

"Our military training too is different from our opponents'. The gates of our city are flung open to the world. We practice no periodical deportations, nor do we prevent our visitors from observing or discovering what an enemy might usefully apply to his own purposes. For our trust is not in the devices of material equipment, but in our own good spirits for battle. So too with education. They toil from early boyhood to a laborious pursuit after courage, while we, free to live and wander as we please, march out none the less to face the selfsame dangers.

"We are lovers of beauty without extravagance, and lovers of wisdom without unmanliness. Wealth to us is not mere material for vainglory but an opportunity for achievement. . . . We differ from other states in regarding the man who holds aloof from public life not as "quiet" but as useless. We decide or debate, carefully and in person, all matters of policy, holding that acts are foredoomed to failure when undertaken undiscussed. For we are noted for being at once most adventurous in action and most reflective beforehand. . . .

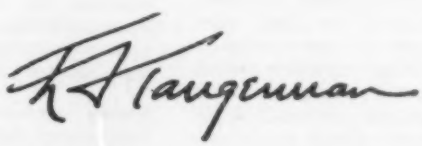
"We secure our friends by not accepting favors but by doing them. We are alone among mankind in doing men benefits, not on calculations of self-interest, but in the fearless confidence of freedom. . . ."

These are extracts from a speech made by Pericles, leader of the Athenians about 430 BC, at the end of the first campaign in the war with Sparta. These two city-states bear more than a vague resemblance to current countries and current ideas, so his words have current application.

Pericles lived in a simpler time. His "state" numbered only about 170,000 souls, but it was the source of much of our basic knowledge of mathematics and geometry as well as of the arts and architecture. He was responsible for their encouragement, had Socrates and Herodotus as personal friends. But, he didn't always practice the principles he preached, so he drew criticism, and on occasion, defeat.

As we celebrate the anniversary of our own declaration of freedom, it is fitting that we consider the words of Pericles almost 2400 years ago. They prove that the principles of democracy endure.

The price is eternal vigilance, which today, as then, must be paid by everyone. Said Pericles in conclusion: "The whole earth is the sepulchre of famous men; and their story is not graven only on stone over their native earth, but lives on far away, without visible symbol, woven into the stuff of other men's lives."



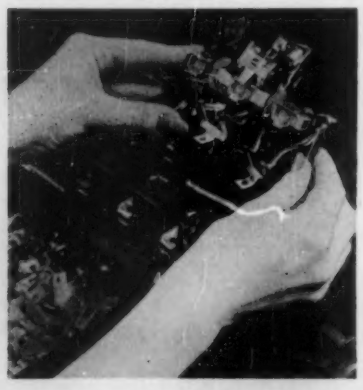
(Advertisement)

Important facts to know about Laminated Plastics

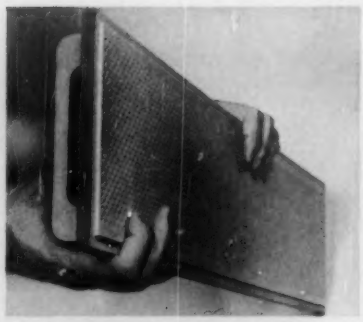
LAMINATED PLASTICS *What they are, where they can be used*

Taylor laminated plastics, also known as reinforced plastics, are thermosetting-type materials formed by impregnating paper, cotton cloth, asbestos, glass cloth, nylon or other base materials with synthetic resins and fusing them into sheets, rods, tubes and special shapes under heat and pressure. These materials exhibit a valuable combination of characteristics, including high electrical insulation resistance, structural strength, strength-to-weight ratio, and resistance to chemical reaction; also adaptability to fabricating operations.

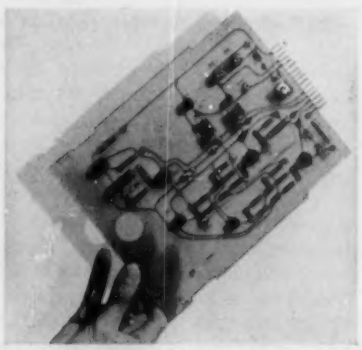
Types of laminated plastics made by Taylor
There are four basic types of Taylor laminated plastics commonly specified and used throughout industry today. They are as follows:



Phenolic Laminates. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde resins. These provide strength and rigidity, dimensional stability, resistance to heat, chemical resistance, and good dielectric characteristics. Some Taylor grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Others are widely used in terminal boards, switchgear, circuit breakers, switches, electrical appliances and motors. Also in radios, television equipment and other electronic devices; and in missiles as nose cones, exhaust nozzles, and combustion chamber liners.

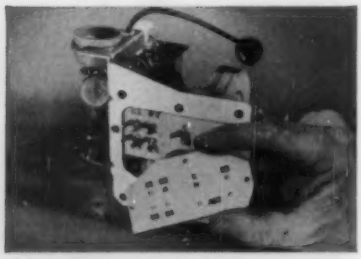


Melamine Laminates. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. Taylor melamine laminates have superior mechanical strength and are especially desirable for their arc-resistant qualities. Good flame and heat resistance, good resistance to the corrosive effects of alkalis and most other common solvents, besides other favorable characteristics. Typical applications include arc barriers, switchboard panels, and circuit-breaker parts in electrical installations.



Silicone Laminates. Continuous-filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F. continuous) with excellent electrical and mechanical properties. They are primarily used in high-temperature electrical applications and high-frequency radio equipment.

Epoxy Laminates. Continuous-filament woven glass fabric or paper impregnated with epoxy resin. Glass-fabric grades are designed for use in applications requiring high humidity-resistance, good chemical resistance,



and strength retention at elevated temperatures. Paper grades are used under high-humidity conditions where resistance to acids and alkalis is required. Both grades are characterized by good dielectric strength, low dielectric losses, and high insulation resistance even following severe humidity conditions.

• • •

Recent technical advances in the bonding of various metallic and nonmetallic materials to laminated plastics have opened up new design opportunities. It is now possible to bond virtually any compatible material with a laminated plastic to form a composite which combines the advantages of both. One of the first composite materials was a copper-clad laminate used for printed circuits. More recent composite laminates, usually manufactured to customer specification, include the following: Taylorite® vulcanized fibre-clad, rubber-clad, asbestos-clad, aluminum-clad, beryllium-copper-clad, stainless-steel-clad, magnesium-clad, and silver- and gold-clad. Any one of these materials can be sandwiched between sheets of laminates, too, and can be molded to fit specific requirements.

Send for complete information about any or all of these Taylor laminates. And remember Taylor's new selection guide will simplify your problems in choosing the right laminate for your specific application. Taylor Fibre Co., Norristown 39, Pa.

Taylor
LAMINATED PLASTICS ■ VULCANIZED FIBRE

CIRCLE 26 ON READER SERVICE CARD

DEMAGNETIZE BEFORE ASSEMBLY

JOHN N ENGELSTED, *president*
O S Walker Co Inc

Without this warning among your drawing notes, machine parts accidentally magnetized during fabrication can create a variety of troubles in the finished assembly. But you have to know something about the metal and its history of magnetization, or the command may be no more than a wishful plea.

The mysterious force of magnetism, is vital when you design electrical machinery—but can be a source of unending nuisance in mechanical equipment. In a delicate mechanism like a watch, even a small amount of magnetism will completely destroy its usefulness. Not so obvious, perhaps, is the effect of magnetism in more robust machinery—but consider what would happen if a magnetic field pulled abrasive filings between the teeth of mating gears. Such hazards, though not widely recognized, are common when machine parts are made from ferromagnetic materials (iron, nickel and their alloys are the most familiar).

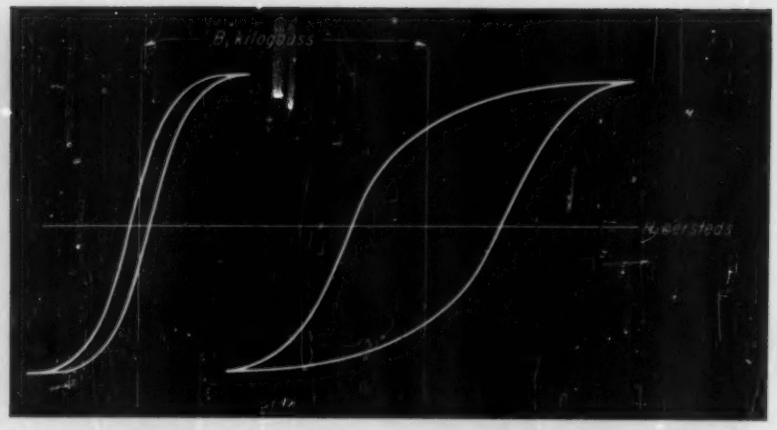
Magnetization in the machine shop is difficult to avoid, particularly if parts are held on magnetic chucks during some stage of the production process. The only answer in these cases is demagnetization. But this is more difficult than it appears. How strong should the demagnetizing field be? What is the permissible level of residual magnetism and how can you be certain that the field has been reduced to this level on all external surfaces?

Three danger areas

Even when residual fields are small, magnetization in a mechanical assembly can inhibit proper operation three ways:

• Parts intended to move freely will stick. Friction between sliding surfaces increases with the added load of magnetic attraction. During automatic assembly, magnetized parts may hang up in feed chutes and magazines.

continued



TYPICAL MAGNETIC MATERIALS are of two types having characteristic hysteresis loops. Soft materials (left) have a long narrow hysteresis loop. Pure iron and pure nickel are perhaps the best examples. Most soft magnetic materials (Permalloy, Hypernik, silicon irons, ferrites, etc.) are those that have been specially compounded for transformer cores, relays, motor and generator frames. Hard materials have a hysteresis loop that is more nearly square. The Alnicos and the cobalt and tungsten steels are best known. Common structural materials such as stainless steel, carbon steel, chrome steels, will be magnetically soft or hard depending on heat treatment and processing.

• Minute particles of steel will cling to parts, jam between mating surfaces, and damage carefully prepared finishes. When close-fitting parts are magnetized, tiny filings picked up during assembly cannot be removed. When the machine is run, these parts will become a further collecting place for magnetic dirt circulated with lubricating oil.

• In electromechanical equipment, a rapidly moving magnetized part can generate currents in nearby conductors. Even if the magnetized part does not cause trouble itself, it may induce fields in other parts where magnetism is more critical.

Magnetization in ball and roller bearings is a common troublemaker. Bearing manufacturers have found that field densities of only 10 gauss will cause balls of average size to stick in delivery chutes during assembly. (For comparison: 4000 to 5000 gauss is about average for a common horseshoe magnet whereas the magnetic field of the earth, in our latitudes, is bewteen ½ and ¾ gauss.) Even weaker fields will cause the bearing to pick up magnetic particles. In critical applications, residual fields in rings, races and balls must be reduced to 1 gauss or less. However a more practical limit of 2 or 3 gauss is considered acceptable for many applications.

Suppose you have two identical ballbearings, both magnetized. Measurements show both have a field of 50 gauss on poles running across their diameter. Without knowing their history of magnetization you put them through a low-power demagnetizer and find that after treatment one has lost practically all magnetism while the other retains its full field of 50 gauss. To understand how this can happen we will have to take a closer look at what is known of the phenomena of magnetism.

The nature of magnetism

Ferromagnetic materials are broadly classified as either "hard" or "soft." The terms refer to their magnetic properties although in many common materials they apply equally well to physical properties. Soft magnetic materials are easily magnetized and easily demagnetized, and are the best materials for electromagnet cores, transformer laminations, vibrators, relays, etc. Hard magnetic materials are difficult to magnetize but retain much of their magnetism, once magnetized. They are most commonly used for permanent magnets.

According to theory, the atoms of a magnetic material each have a small magnetic field generated by their orbiting electrons. But rather than making individual contributions to the total field, the atoms act in small clusters which have a magnetic axis oriented in one principle direction. The vector sum of these atomic fields determines the intensity of the total field created by the part.

To draw an analogy, atoms in a solid are like grapes in a crate. They are not heaped together loosely but are clustered together in bunches—and the stem of each bunch represents the principle magnetic axis. In the demagnetized state, the axes of the bunches are scrambled in all directions so that their effects cancel, giving a vector sum of zero. When an external field is applied, some of the axes turn to align with the field. After the field is withdrawn, the reoriented clusters maintain their new alignment, causing a residual external field.

Physicists call these clusters "domains." The size of a domain is not necessarily related to the size of a grain in polycrystalline material—it is usually much smaller. Single crystals, in fact, often have several of these small magnetic domains contributing to a resultant magnetic field.

Magnetization in steps

Passing a magnetic field through a demagnetized ferromagnetic material causes domains to react in two ways: Those not aligned with the external field are forced to change the direction of their magnetic axis; those that are closely aligned grow at expense of domains less favorably oriented. As strength of the magnetizing field increases, more and more domains line up until all domains point in the same direction. The material is now saturated; it will not carry additional flux even with increased magnetizing field. When the magnetizing field is removed, some domains return to their original condition while others remain aligned. The amount of residual magnetism depends on the number that stay aligned.

The gradual alignment of magnetic domains was first demonstrated by H. Barkhausen in 1919. He wound a coil around a steel bar and passed a gradually increasing current through it. Listening with headphones connected to a sensing coil wrapped around the bar at another point, he heard faint clicks as the magnetic field increased. These clicks, he reasoned, indicated a sudden increase in flux as domains snapped into alignment. Since that time scien-

HYSTERESIS LOOPS DESCRIBE MAGNETIC PROPERTIES

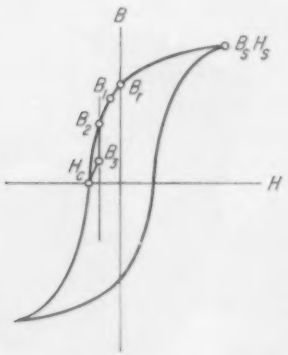
• Demagnetizing a piece of ferromagnetic material requires an understanding of how that material acts in the presence of a magnetic field. If you wrap an iron bar with N turns of wire, you have a very simple electromagnet. A current passing through the coil generates a magnetic field whose strength H (measured in oersteds) is a function of the current I and the number of turns N.

$$H = \frac{0.4\pi NI}{l}$$

where l is the length of the magnetic circuit. This applied field induces a field (measured in gauss) in the iron bar. If the bar were removed from the coil, the strength of the field in air (in gauss) would equal the applied field in oersteds. But the bar concentrates the field and increases the density of the induced field B in proportion to the material's permeability, μ (for air, $\mu = 1$).

$$B = H\mu$$

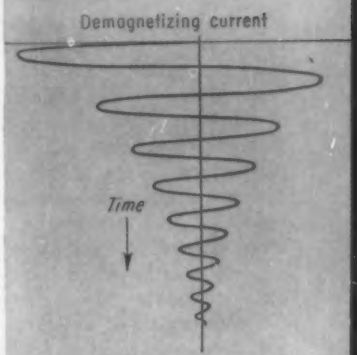
The relationship between the applied field H and the field it induces B is usually plotted as a hysteresis loop.

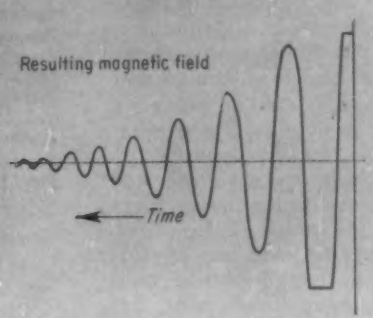


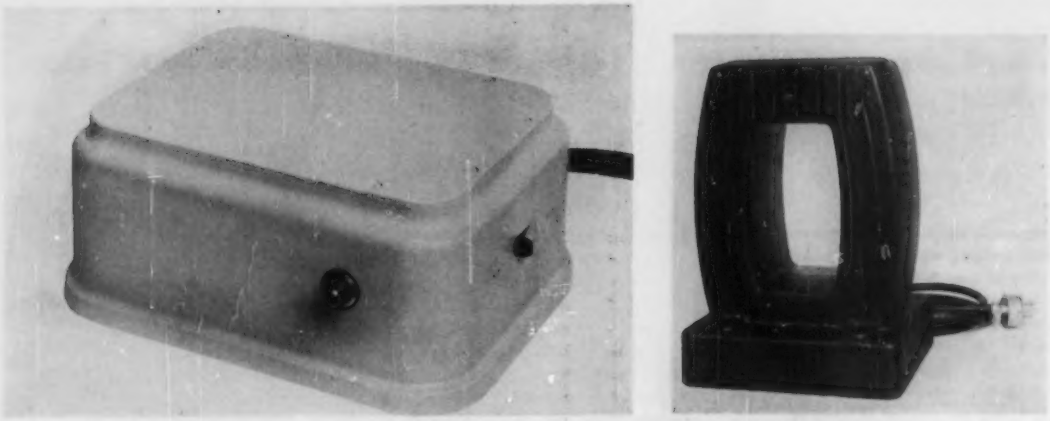
If the applied field is sufficiently large, the material will be driven to saturation at $B_s H_s$. When the field is removed, a residual field remains. The intensity of this field depends not only on configurations of the hysteresis loop, but on shape of the magnetic circuit. In the case of the iron bar, the residual magnetization may drop well down on the demagnetizing part of the curve to a point equivalent to B_2. This is because the flux travels only a short distance through the bar and a relatively long distance through the air, resulting in a large "self-demagnetizing" force. With a shorter air path—a horseshoe magnet, for example—the flux would drop only to B_1. And if the horseshoe magnet had a keeper across its poles (making a complete magnetic circuit) the full field B_r, will remain when the electrically induced field is removed.

Suppose you attempt to demagnetize the bar with a reverse field of H_c oersteds. The flux in the bar changes from B_2 to zero, but when the demagnetizing field is removed, self-demagnetization causes the value of the residual flux to return along a minor hysteresis loop to B_3.

Clearly, then, there is no one reverse dc field that will bring the residual magnetic field back to $B = 0$, $H = 0$ throughout the entire sample. The part must be demagnetized by an alternating field. This is done as shown in the diagram at right. The ac field first drives the part to saturation in both directions. This applied field is then diminished exponentially causing the material to traverse smaller and smaller minor hysteresis loops. Thus the induced field also decays exponentially until the applied field is too small to have any effect and the hysteresis loop closes in on $B = 0$, $H = 0$. •







COMMON DEMAGNETIZERS are made in either of two standard forms. Core-type demagnetizer (left) has its pole pieces terminating at a plate. A part is demagnetized by simply sliding it slowly across the plate, passing it clear of the demagnetizing field. The plate on this one is about as large as a sheet of typewriter paper. The unit plugs directly into ac line, draws 18 amps. Aperture demagnetizer (right) removes residual fields when workpieces pass through the opening. The effect is the same as if the piece were wrapped with a coil of wire carrying an alternating current. This type is most common in production demagnetization setups and is frequently placed so that the delivery chute passes through the aperture. Unit shown includes patented compensating circuit which decreases idling current and increases operating current.

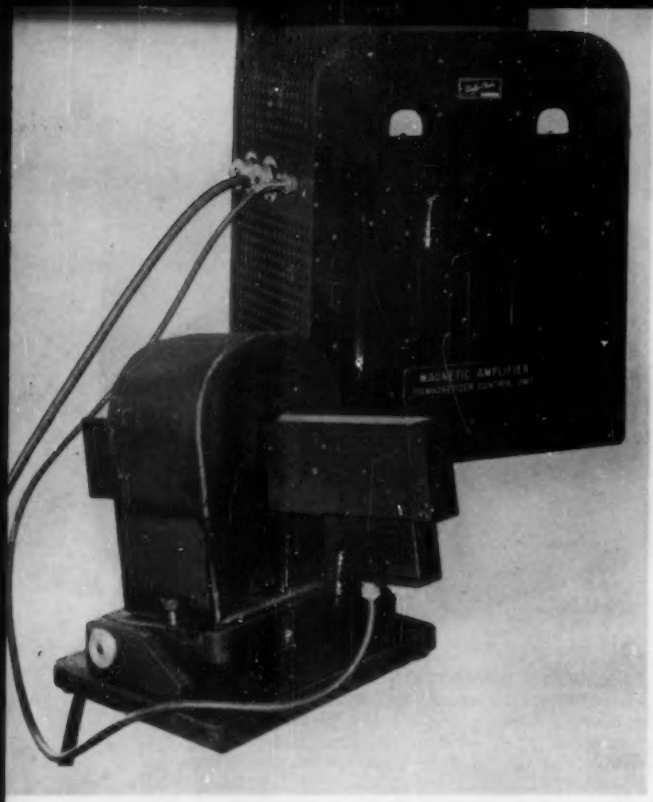
tists have developed more elaborate experiments to show the growth and realignment of domains.

These fundamental physical principles explain why it is necessary to know something of the magnetic history of a part before attempting to demagnetize. The domains in soft magnetic materials are more fluid while magnetically hard materials have a larger proportion of highly resistant domains. But any magnetic material, whether soft or hard, will have some domains that are more mobile than others and they will line up with only a small magnetizing field. In a hard magnetic material, for example, the easy domains will line up first but a very high field may be needed to align the more resistant domains. Demagnetization is a similar process: mobile domains are scrambled easily while more resistant domains become disoriented only with very large fields.

Consider the case of the two identical bearings. Though both have only 50 gauss residual field, they have different histories of magnetization. One was magnetized only to the point where 50 gauss remained when the magnetizing force was removed. The other was magnetized to saturation, then demagnetized to the 50-gauss level. In the latter case, only the most resistant domains remained aligned. This explains why it was unaffected by a demagnetizer that completely demagnetized its twin. Only with a demagnetizer about 10 times as powerful as that used on the first bearing can the resistant domains be moved.

This situation can easily occur in production. Suppose that at some point in the manufacturing process, parts are held on a magnetic chuck for surface grinding. Most parts will be held in full contact but some may be separated from the chuck surface by a small sliver of steel. With the area of contact reduced to a small point, flux

FOR LARGE SURFACES such as machine-tool ways, this portable roller will wipe away external magnetic poles that would otherwise attract abrasive magnetic grit. When inverted and mounted on a bench, it can be used to demagnetize long bars by pulling them over the roller.



MOST POWERFUL DEMAGNETIZER has magnetic amplifier control circuits to keep it from burning out and simultaneously increase its power. These circuits give a powerful surge of current when the workpiece first enters the aperture. This field immediately starts to decay and by the time the part has left the coil the current has dropped nearly to zero.

concentrates and affects all of the easy domains and some of the harder ones in this small area. Consequently, this part will stubbornly resist the same demagnetizing operation that is completely effective for the majority of parts.

Tools of demagnetization

Handbooks and textbooks suggest several ways to demagnetize ferromagnetic parts. Perhaps the oldest (and the most impractical) is heating the part to red heat (above 1400 F), then letting it cool with its major axis pointing east and west. This severe treatment will most certainly do the job (any material will lose magnetism when heated above its Curie point) but it's out of the question for most precision parts.

The most common way to demagnetize is with an overpowering alternating field that is gradually reduced to zero either by slowly removing the part from the field or by diminishing the alternating current in the field coil. The effect of this is to magnetically saturate the part in one direction, then the other. As the field is reduced, fewer and fewer domains follow the alternating orientation of the external field until, at very small alternating currents, only the more mobile domains remain. As current diminishes to zero, the field is able to switch fewer and fewer of these easy domains until all are left randomly oriented.

Frequency of the field depends on the size of the piece being demagnetized. If the field is reversed too quickly it may not have an opportunity to penetrate deep into the part and only the surface will be demagnetized. This has been the cause of many unpleasant and confusing surprises. When demagnetizing a large forging with a 60-cycle demagnetizer, production shops occasionally find that the job has not been thorough. Although the part seems to have lost all its residual magnetism, very powerful magnetic poles suddenly appear when it is machined. In this case, the demagnetized outer surface acts only as a path for flux between internal poles. Removing this outer layer is analogous to machining the keeper off a horseshoe magnet.

Two types of demagnetizers are in common use. Both have the same goal: to pass a large (but diminishing) alternating flux through the workpiece. The first is the "aperture" demagnetizer, simply a coil through which the magnetized part passes. The coil carries an alternating current and has the same effect on the part as if the coil were wound around it in the fashion of an electromagnet. The second type, the "core" demagnetizer, has a laminated iron core with the magnetic circuit open on one side. The piece to be demagnetized is placed across the pole pieces, thus completing the magnetic circuit.

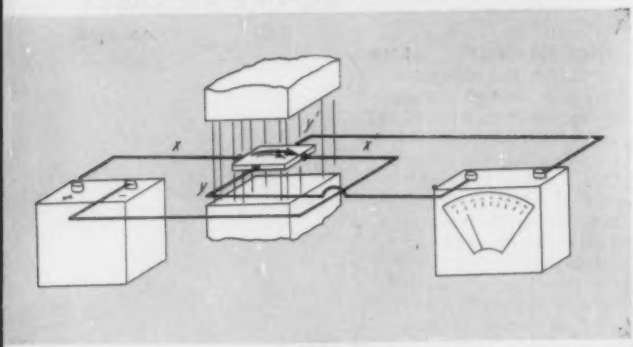
Most demagnetizers are powered directly from the ac lines. In most cases the field is mechanically diminished after applying full power by moving the part away from the demagnetizer. However, it is necessary to take care that the part is well away from the field when the switch is turned off. The large currents passing through the coil as the field collapses can easily remagnetize the part.

Control circuits improve effectiveness

The power of an aperture demagnetizer can be increased considerably with a compensating circuit developed some years ago by an engineer of this company. The circuit automatically increases the current in the demagnetizer when the workpiece is placed in the coil; the larger the piece, the greater the field. This also offers two additional advantages. The current drops to a low level when the demagnetizer is idling, preventing destructive heat buildup. Also, the workpiece can be passed through the coil with less mechanical force than would be necessary if the field remained constant.

For the same reason, saturable reactor controls are also used with demagnetizers. They provide a sudden surge of current when the piece is introduced into the aperture. The current then decays at a suitable speed to provide effective demagnetization. If fitted to a gravity-feed chute, parts will be stopped in the aperture by the surge of current and, in a few seconds, will roll free as the field decays.

The size and type of demagnetizer chosen will depend on the shape of the parts as well as degree of demagnetiza-



HALL-EFFECT GAUSSMETER measures fields directly in gauss; this one gives full-scale readings from 3 to 30,000 gauss. The probe is 0.025 in. thick, 0.2 in. wide; has an active area near its tip, only 0.01 in. square. Sketch illustrates Hall effect. A current-carrying semiconductor material is placed perpendicular to the lines of flux in a magnetic field. This causes electrons moving in the x-x' direction to be deflected in the y-y' direction and they pile up at one edge of the semiconductor. This electric field is measured by the y-y' electrodes.

PRODUCTION INSPECTION OF BEARINGS is speeded with this instrument. It automatically rotates the bearing while a small probe measures strength of magnetic poles on bearing race. Reject bearings are indicated by readings on the meter.

tion required. It is important that it be no larger than that actually needed to do the job. The cost of simple demagnetizers increases roughly in proportion to their power, and the cost of superpower units jumps significantly because of the control circuits needed to protect them from burn-out.

In matching the demagnetizer to the workpiece, the physical dimensions of the device should be close to that of the part. Demagnetizing a small part in a large-aperture demagnetizer will call for power many times that needed to do the same job with a small unit. A demagnetizer of optimum dimensions will do a much more effective (and much less expensive) job, provided it has sufficient power.

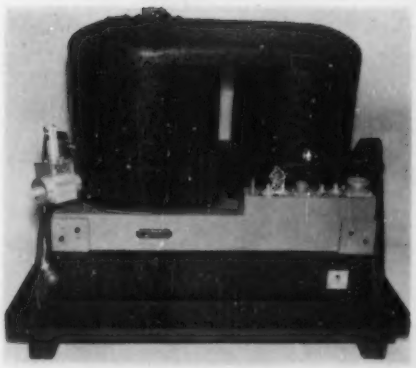
Small parts are sometimes demagnetized collectively by passing them through the demagnetizing field in a tray or tote pan. If they are piled randomly in the pan, it may not be possible to demagnetize all to the same degree, particularly if they are of a hard magnetic material. In these cases, it may be necessary to handle the pieces individually to ensure satisfactory results.

The residual field desired depends, of course, on the application. In some cases, 10 to 20 gauss will not cause trouble; in other cases magnetization must not exceed 1 gauss. In any event, the earth's geomagnetic field of ½ to ¾ gauss represents the lower limit of residual magnetism.

Measuring instruments

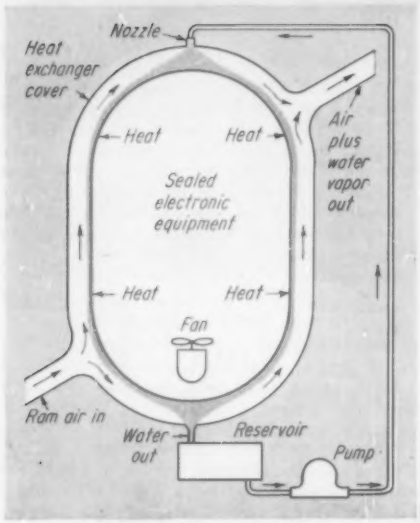
A common way to measure residual fields is with an ordinary magnetic compass. Compass needles deflect vigorously in fields of less than 1 gauss. But they have a disadvantage: A compass is a relatively large sensing instrument and will detect only those magnetic poles separated by a distance roughly equal to the size of the needle. More closely spaced poles will be automatically averaged out and may go undetected even though they have a magnitude of several gauss.

A better measuring instrument is the "Hall effect" gaussmeter. It will measure poles as close as 0.01 in. The principle of operation is based on a phenomenon of certain semiconductor materials. A probe with an active semiconductor tip develops a signal which is amplified and appears on a meter that reads directly in gauss. Production instruments which operate on the same principle are also available. ■

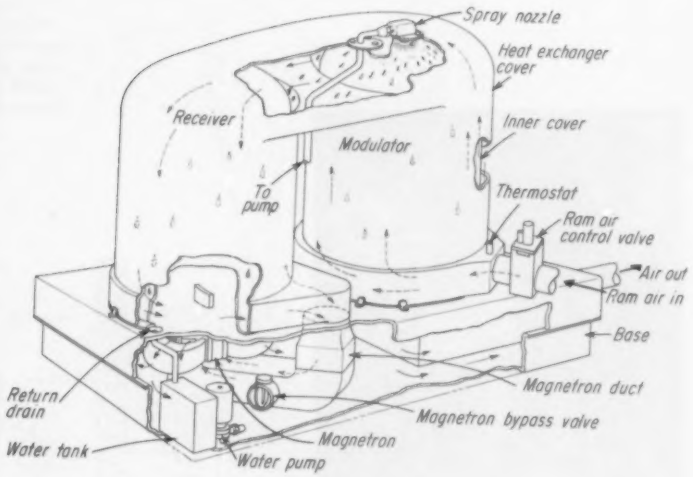


Spray Cools Black Boxes

Two-phase system simplifies cooling of airborne electronics package. Ram air at low level, and evaporative cooling at high levels, prevent sealed radar from overheating.



RADAR TO BE COOLED is enclosed in a sealed container to prevent arcing at high altitudes. Heat exchanger cover is connected to ram-air supply. As long as the inlet air is below 120 F, inlet valve stays open and unit is cooled by ram air alone. Above 120 F a thermostat moves inlet valve to closed position and starts a circulating pump. In closed position, inlet valve reduces airflow to 10% of its former volume. The circulating pump sprays water over the inner container, wetting the entire surface. Result: air exits from the top of the heat exchanger cover at a lower temperature and increased humidity. Temperature of water leaving the bottom is the same as that of the entering water under equilibrium conditions.



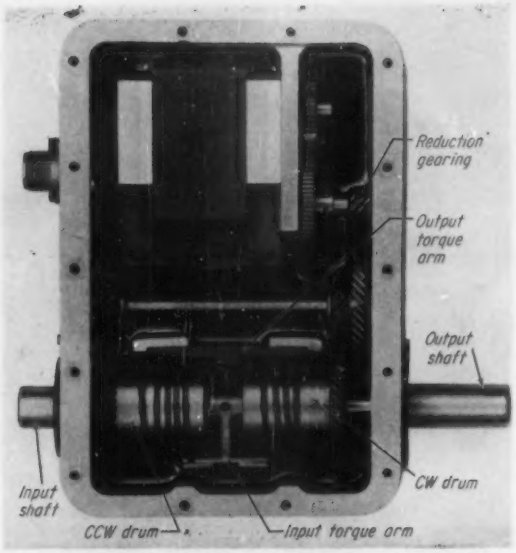
SPRAY NOZZLE, mounted directly above the pressurized modulator cover, delivers 60 lb of water per hr at 15 psi. Some water is evaporated and lost but approximately 95% flows down the modulator and receiver case, and back to the water tank through drain lines.

Cooling air enters the package through the ram-air control valve, flowing up and over the modulator cover in the annular space between the pressurized cover and heat exchanger cover. It next flows over the top and down the annular passage surrounding the pressurized cover of the receiver. Ducts lead the air down into the base where it flows over the magnetron fins and other equipment and out the side. A bypass in the magnetron duct reduces airflow to it during ram-air cooling.

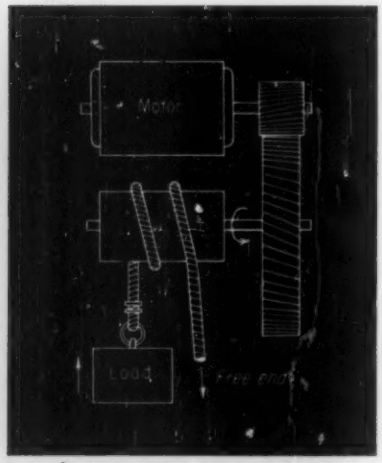
PS . . . Total heat dissipation required in the radar set is approximately 1000 watts. Water consumption is 4 lb per hr with a ram-air inlet temperature of 180 F. Packaged unit provides the proper environment for radar equipment at speeds up to Mach 2 with an inlet temperature of 300 F. Developed by Convair, Div of General Dynamics, San Diego, Calif for US Navy's BuAer.

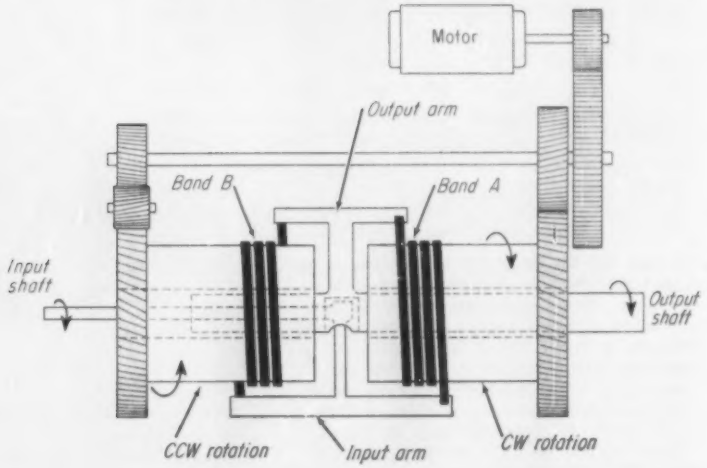
Amplified Muscle Gives Control

Mechanical power amplifier adapts ancient ship's capstan to up-to-date control problems. Dual drums provide bidirectional operation plus accurate angular position.



AMPLIFIER IS ENCLOSED in sealed case with input shaft and output shaft protruding. Any rotary signal source (electric, hydraulic or pneumatic) connected to the input shaft can be used to control the output. Output shaft responds to less than 1° rotation of the input control shaft with an accuracy of better than 1°. Slippage of the bands permits the application of a variable speed pattern at the input to obtain a duplicate of the pattern at amplified torque at the output shaft.

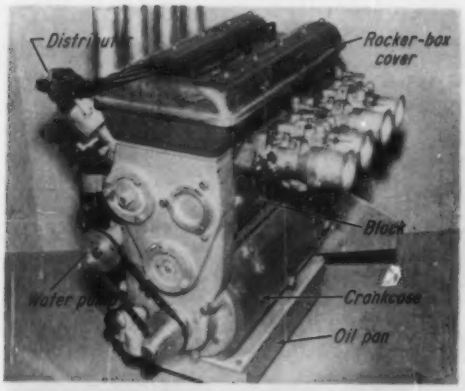




CAPSTAN is simple mechanical amplifier—rope wound on motor-driven drum slips until slack is taken up on the free end. Force needed on free end to lift the load depends on the coefficient of friction and number of turns of rope.

By connecting bands A and B to an input shaft and arm, the power amplifier provides an output in both directions, plus accurate angular positioning. When the input shaft is turned clockwise, the input arm takes up the slack on band A, locking it to its drum. Inasmuch as the load end of locked band A is connected to the output arm, it transmits the CW motion of the driven drum on which it is wound, to the output shaft. Band B therefore slacks off and slips on its drum. When the CW motion of the input shaft stops, tension on band A is released and it slips on its own drum. If the output shaft tries to overrun, the output arm will apply tension to band B, causing it to tighten on the CCW rotating drum and stop the shaft.

PS . . . An amplication factor (output to input torque ratio) of 500:1 provides wide range of possible applications in machine-tool control, variable-speed drives and remote-positioning devices. Output shaft delivers 20 lb-ft of torque at any speed up to 196 rpm. Power unit for this amplifier is a ¾-hp 1750-rpm electric motor. Mechanical power amplifier type 69A03-1 is produced by Armament Div. of Universal Diamond Match Corp, St. Louis.



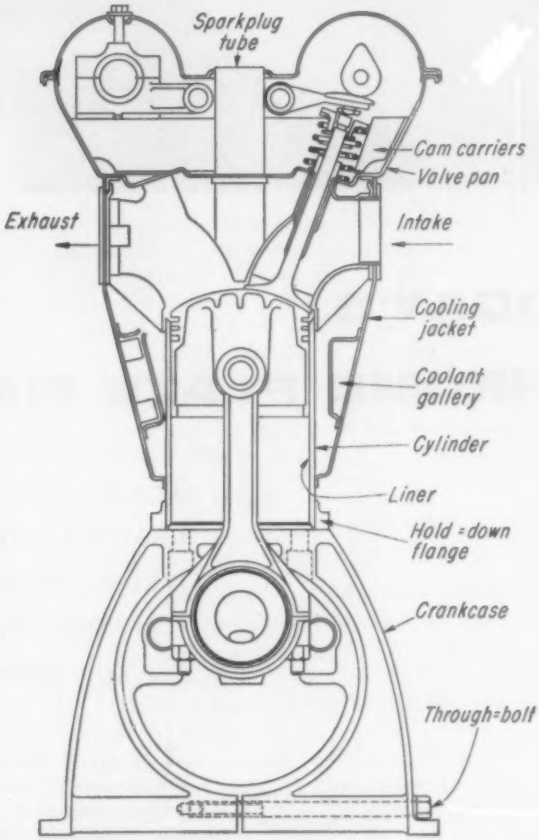
BLOCK AND HEAD are metal stampings fabricated into single unit by brazing. Half sections of each cylinder-head are stamped from 0.090-in. stainless steel—restruck in a coining die to get final shape and to keep wall thickness uniform. Cylinders are sections of tubing into which a 0.063-in. liner of 4130 steel is inserted. Cooling jacket is produced by punching stainless sheet and bending it over a forming block. A one-piece stamped oil pan is used to close top of cooling jacket and provide a base for the camshaft mountings.

Before brazing, the cylinder, cylinder-head halves, cooling jacket, oil pan and sparkplug tubes are held in position by tack welding. Then the projecting cylinder bases are pressed into a cast-steel hold-down flange, and a threaded collar inserted into the sparkplug socket. Unit is next oven-brazed at 2000 F, using copper foil and wire installed during assembly. Close fits of coined stampings and tack welding eliminate need for jigs during brazing. Low surface tension of molten copper results in the entire block-head assembly being copper plated for excellent corrosion resistance.

PS . . . Lightweight (175-lb) engine is produced from steel stampings and aluminum alloys. "Block-on-head" construction eliminates head gasket, permitting higher compression ratios (14:1) with safety. Four sizes are produced: 91 cu in., 115 hp; 105 cu. in., 125 hp; 120 cu in., 150 hp; and 135 cu in., 175 hp. All engines use 3½-in. bore, stroke is varied for different displacement. TnT engines, suitable for cars, boats or aircraft ground-support equipment, are produced by Tyco Engineering Corp, Chula Vista, Calif.

Brazed Engine—Raised Performance

Block and head are fabricated as a single unit from metal stampings—no head gasket needed, and engine output exceeds 1 hp/cu in. Uniform thickness of cylinder wall prevents hot spots.



CRANKCASE AND BLOCK-HEAD UNIT are connected by bolts through the hold-down flange. Main bearings are mounted in flanges, which are clamped in the split crankcase by through-bolts. When assembling, the crankcase is wedged open slightly and the crankshaft, with the three center main-bearing flanges mounted on it, is slipped in from the end. Through-bolts at the crankcase base clamp the crankshaft flanges to prevent movement.

The camshafts run in five cast-aluminum, heat treated bearings, mounted on cam carriers set in the valve pan atop the cooling jacket. Camshaft bearings are bolted to weld-nuts brazed to the cam carriers. Coolant is distributed by galleries mounted on the cooling-jacket walls beneath the intake and exhaust ports. Base of the crankcase is closed by a shallow aluminum sump, from which the oil pump feeds.

ROAD TESTS FOR CHROME PLATE evaluate Pontiac's new plating combinations. Here, plated specimens mounted on bumper show typical road corrosion.

TODAY'S CHROME PLATE FINISHES

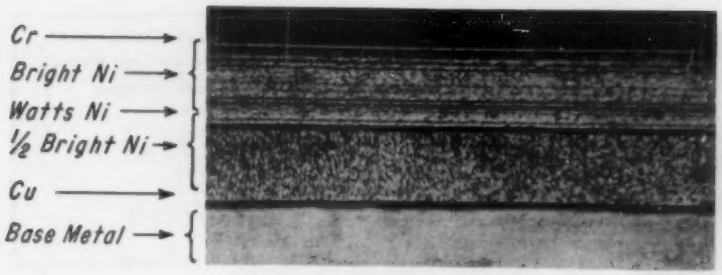
The car owner's desire for a durable chrome finish has put Detroit on its mettle. Result is new electroplates—duplex chromes and duplex nickels—with increased corrosion resistance. This article relates the new finishes to the old.

FELIX GIORDANO
Our Detroit Editor

The aim of chrome plating is decoration—to provide a finish pleasing to the eye on zinc diecastings, stamped steel and brass parts. Corrosion enters the problem only as it spoils the appearance of the finish, even though the plating does protect the part itself from damage. What you see is the chromium top layer—only part of what is called the finish. To keep it from corroding, as well as to make it adhere, it must go on over a combination of subcoatings. The newest finishes now employ double layers of chrome or nickel—and even combinations of these. The superior protection they give, as shown by careful testing in automotive applications, makes them well worth considering—even though they cost more than conventional copper—nickel—chrome systems.

The New Electroplates

Duplex-nickel plate gives better protection, although it is more expensive than duplex chrome. The coating consists of two nickel layers: A semi-bright nickel plate columnar in structure and a fully bright nickel plate that



CHROME FINISH having maximum adhesion and long life uses a Watts-type nickel strike between the duplex nickel layers. Note thickness of the coating sublayer components compared to the final chromium layer.

has a laminar structure. The latter provides a highly reflective base for later chrome plates. Because the bright nickel plate is anodic to the semibright nickel, any corrosion that penetrates the top nickel layer changes its direction and proceeds laterally. On steel base-metal this general attack is slow compared to the penetrating crack-type corrosion that shows up as small spots of rust or other corrosion products. Protection given by duplex nickel is roughly 4 times that of an equivalent thickness of standard nickel plate.

In practice, a third nickel electroplate is used to promote adherence between the two layers. This adhesion layer, called a "strike," is a thin layer of the nickel put on by a Watts-type solution.

Duplex-chrome plate combines the durability of hard conventional chrome plate with the better corrosion resistance of crack-free or nonporous chrome plate. Top layer is the conventional hard chrome plate, which retains a bright decorative appearance because it resists abrasion and scratching. Bottom layer is a crack-free chrome plate which effectively seals off the base metal or coatings below. Because such chrome layers are thinner than nickel plates, they do not boost corrosion resistance as much.

Other new processes include special copper baths which give a level copper sub-layer that doesn't require buffing after plating. The mechanical buffing removes some of the copper layer and increases costs as well. The leveling copper baths are not yet commercial because they have these major faults: The acid leveling baths cannot be used for zinc diecastings because they attack the metal; the alkaline baths contain cyanide as the major constituent so are difficult to dispose of after the bath is used.

The Chrome-plating Combinations

Copper–nickel–chrome is the traditional sequence for steel. Protection from corrosion is increased by increasing thickness of the various layers, usually the nickel plate. Maximum protection can be achieved only by heavy layers and these are costly because such platings do not make efficient use of material.

Nickel–chrome, normally for coating brass, is sometimes chosen for steel to avoid formation of a copper-steel galvanic couple. Eliminating the copper cuts cost of material but the base metal, whether brass or steel, has to be buffed more before plating to meet decorative requirements of high luster and easy cleaning. Buffing the steel rather than steel and copper plate often costs more than the amount saved on materials.

Copper–duplex nickel–chrome is used to withstand more severe corrosion. Here, duplex nickel is substituted for standard nickel in the conventional Cu–Ni–Cr plate. This adds to cost (duplex-nickel baths are more expensive) but total thickness of deposited nickel remains about the same.

Duplex nickel–chrome (without copper) is a variation of the nickel-chrome process with the advantage of the duplex nickel layers.

Nickel–duplex chrome replaces the semibright nickel of the duplex nickel coating with one of less expensive chrome.

Duplex nickel–duplex chrome (with or without the copper underlay) is not used commercially on a production basis. It gives better corrosion protection than combinations that plate with either duplex nickel or the duplex chrome.

Variables in corrosion atmospheres and combinations of different layer thicknesses cause differences in results. Generally speaking, if the choice is between duplex nickel or a duplex chrome, choose nickel for its longer life–despite the higher cost.

Copper as an initial underlay has high ductility that allows it to flow when buffed. This is an effective and inexpensive way to provide a smooth base for deposition of subsequent platings. Buffing of the copper layer also reduces its porosity, minimizing the chances of corrosion penetrating to the base metal.

Thicknesses of Layers

For most outdoor applications, the following thicknesses will generally give satisfactory service.

Copper plate should have a deposited thickness of 0.001 in. Buffing reduces this to about 0.0008 in.

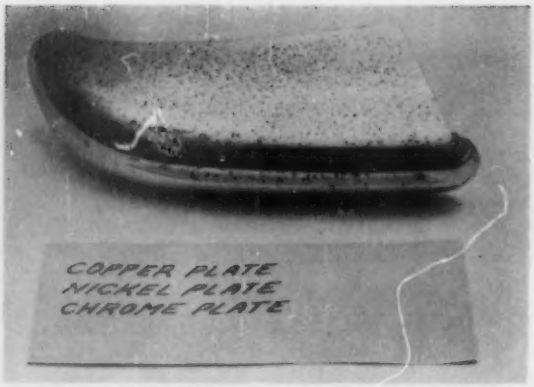
Nickel should be at least 0.001 in. total. If no copper is used, thickness should be increased to 0.0013 to 0.0015 in. In the duplex nickel plate, the total thickness is divided between the two layers.

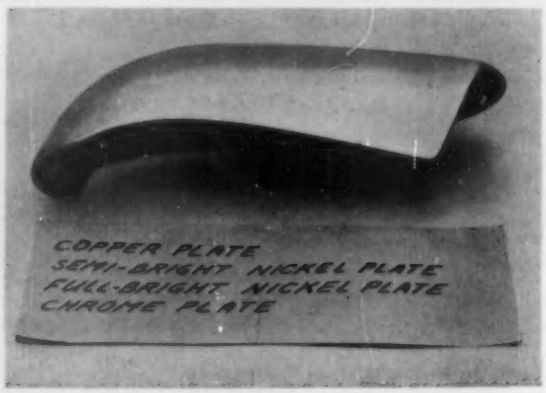
Chrome plate runs from 0.000,02 to 0.000,03 in. for the standard chrome plate. Duplex chrome deposits are about 0.000,06 in. total, evenly divided between the two layers.

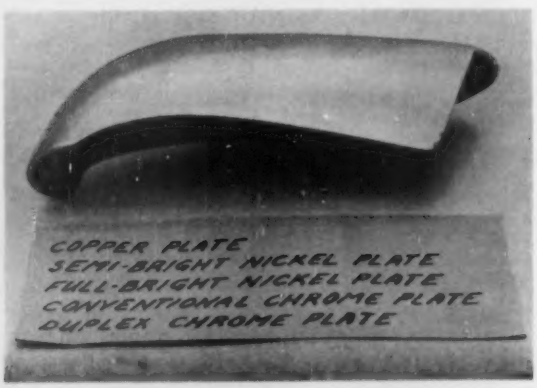
For indoor applications, all deposits are reduced. Copper is 0.0003 in. and is not buffed after plating. Nickel is 0.0005 in. and always deposited in a single fully bright layer. Chrome, also a single layer, is 0.000,01 in.

Plating Costs

Expense of plating depends on how completely the equipment is mechanized. Once an automatic plating line is set up, labor costs remain essentially the same for a given number of parts. The only labor required is for loading and unloading the parts. The number of baths adds to expense







GOOD, BETTER, BEST—these three bumperettes show improvement in corrosion life. At top, part is plated with standard Cu—Ni—Cr. Center shows better durability of the Cu—duplex Ni—Cr combination. Bottom, plating with Cu—duplex Ni—duplex Cr retains best decorative appearance.

HOW CHROME-PLATING COMBINATIONS RATE
(from highest to lowest cost and corrosion resistance)

*Copper—duplex nickel—duplex chrome
Copper—duplex nickel—chrome
*Duplex nickel—duplex chrome
Duplex nickel—chrome
Copper—nickel—duplex chrome
Copper—nickel—chrome
Nickel—duplex chrome
Nickel—chrome

* Not production processes

by the cost of the plating solutions but does not materially influence the output or labor. Any interruptions of the plating cycle that require unloading and reloading the parts do increase labor costs.

Plating expense in an automated process can be compared on an area basis. In general, costs per square foot (excluding labor) for each plated layer are: 6.5 cents for copper plate, 13.4 cents for nickel and 0.0013 cents for chromium. Cost of a duplex coating is about double that of a single-layer standard plate. This is true even for duplex nickel where total thickness of plate is the same. This is because the duplex plating baths are more expensive.

Comparative Tests

Chrome-plated parts do not have a finite life. Decorative life—how long a part remains attractive—is purely subjective. What is attractive to one person may not appeal to another. So the best way to judge coating performance is to compare a trial coating with the one that is now standard.

Accelerated tests such as exposure in spray cabinets help in the initial evaluation. Final judgment must be based on performance under actual conditions. A typical program tests the different chrome-plating combinations by exposing them on roofs of buildings in different parts of the country. Other panels are attached to test cars operating in sections of the country that have traditionally given the most trouble from corrosion. Parts like hubcaps and bumper segments, plated by different processes and mounted on the same automobile, give good comparisons of platings under actual road conditions. These test conditions may, of course, be too severe for your product.

The chrome plate, which does not itself deteriorate, gradually loses its brilliance as corrosion products from the base metal beneath deposit on the surface. In most applications, dirt covers the platings long before they fail. Any light-colored corrosion deposits will be removed along with the dirt when the plating is cleaned. Colored corrosion, like rust, is more noticeable. Usually chrome platings are not considered to have failed until the porosity or pinholes become sufficiently large to be visually apparent.

EDITOR'S NOTE: The following articles deal with the various aspects of metal finishing for decorative and for protective purposes:

Plating Parts by Peening Them, Mar 14 '60, p 70—Low-cost method gives corrosion resistance by tumbling with zinc and other metal powders.

Which Vinyl Coating Process for Metal Parts, July 6 '59, p 70—Compares basic methods for coating preformed and post-formed parts.

This Test for Oxidation Resistance, Apr 27 '59, p 48—New technique peers under surface oxide for clues to alloy permanence at air temperatures up to 2200 F.

New Look in Porcelain Enamels, Nov 24 '58, p 53—Covers latest unusual decorative finishes, shows how to consider engineering performance when making the selection.

Textured Steel, Mar 17 '58, p 73—Full-color article shows when to use textured steel, where it's applied; tips on design and fabrication.

Vacuum Coatings Go Industrial, Dec 23 '57, p 67—Data on thicker coatings that are corrosion resistant as well as decorative.

how to design

LIGHTWEIGHT CASTINGS

Efficient use of metal is a must in the instruments and control devices that fly today's rockets and missiles. Here's a step-by-step procedure that shows you how to design strong castings with a minimum amount of metal.

HEMENWAY R BULLOCK, *manager, Metals Laboratory Airborne Operations Equipment Div, Raytheon Co*

Castings are specified for three reasons: reproducibility, the ability to collect tolerances into a single part, and ability to preserve structural continuity. The last reason affects the designer, the first two are properly questions of foundry technique. The casting has been the dearly beloved of the designer because in it he could collect all his uncertainties, and even justify them since the structure in question cannot be subjected to rigid mathematical analysis. But now, better tools of stress analysis are all-revealing. In fact, with present design methods, freedom from failure is virtually a guarantee of excessive weight.

For the design of efficient castings, there are available three modern laboratory stress-analysis techniques. First is use of a resurgent photoelasticity where the transparent material is frozen and local stresses may be obtained by sectioning in any desired plane. Second is use of Stress-coat, a proprietary series of brittle varnishes, which will crack at known values of strain. Third is the PhotoStress technique, which in effect combines photoelasticity and surface measurements by brittle varnish. This third method has led us to a routine approach to design of a casting which has answered our own needs to date, and is summarized below:

Step 1: Make the initial layout involving space and linear dimensions. Such mathematical approximations of strength as can be made should be used here—from beam theory to membrane analysis. This will result in some kind of a strength number. If this is not in error by more than 40% to 50% the results are usable in this method of design. Best results require assumptions which result in high stresses. In other words, underdesign the structure.

Step 2: Construct a full-size mockup, using sheetmetal stiffened with machined flat stock welded together. Depending on need and type of loading, you can use either a very rough approximation or an exact replica of the casting. If elevated-temperature considerations enter the problem, cast bars and flat-cast panels can be machined and welded. Probably a simpler mockup is best in initial design stages.

Step 3: Coat the mockup with PhotoStress plastic and apply the simulated loading in convenient increments. Stress patterns should be observed and recorded photographically, critical areas studied in detail, and stress measurements made. At this stage in Step 3, the merits and deficiencies of the design will appear. Some areas may show dangerous stresses before there are any signs of loading in other areas. In other models, with well-distributed loading, there will appear areas which carry no load at all. Here the material is just going for a ride.

General conclusions may be drawn at this design stage regarding thickness of material, stress raisers, and rib and flange dimensions. It is extremely important to note here that stress relief of the model is an absolute must, following every welding operation or wherever test loads have approached the measured elastic limit of the material.

Step 4: Apply strain-gage rosettes at indicated critical areas to check the magnitude and direction of stress. This step is a matter of choice. We now believe that such slight lack of correlation as exists between strain-gage values and PhotoStress values is caused by inaccurate orientation of the strain gages. It is quite probable that as time progresses the strain-gage checking will be eliminated completely or used only for a check of extrapolation at elevated temperatures. This step may also be extended by changing the configuration of the model, or making a new and more sophisticated one. In any case, the end result of this step should be an adequate and usable component with a definitely known factor of safety in every area.

Step 5: Make a casting. More or less elaborate tests of this initial casting may be made. We repeat the PhotoStress analysis at this stage, since it is amazing how minor variations in things like fillets will affect the stress distribution. We also make local stress-strain plots and metallographic studies to make sure we are using the correct elastic constants.

Abstracted from a talk before a recent meeting of the Society of Aircraft Material and Process Engineers.

getting your share from

TECHNICAL LITERATURE?

The choice is yours. You can spend an hour or so locating what others have published. Or you can plunge right in, eventually solving the engineering problem yourself—and possibly duplicating someone else's work.

HAROLD S SHARP, *technical librarian*
AC Spark Plug Division, General Motors Corp, Milwaukee

Do you recoil in horror when you think of researching "the literature"? Well, you're not alone. Most engineers, and scientists too, are cowed by the overwhelming wordage in the thousands of technical and trade periodicals published each year.

And yet, like you, they realize that there are probably nuggets galore somewhere among the billions of printed words—nuggets of information that will help solve their problems.

But not all technical men are so easily discouraged. There are some who have learned how to use the literature. And they find it one of their most useful—and inexpensive—tools. For here is a legitimate way to pick the brains of others.

How do you use literature as a tool?

First, become familiar with the various indexes that list appropriate publications (see "Here's Where to Look"). In this way, you quickly narrow the search. Second, if your company employs a technical librarian, be nice to him. He (or she) can be a valuable member of your team. Third, decide how much time you are willing to gamble on a literature search.

For instance, say you have four weeks to design and develop a brainchild. You decide to spend eight man-hours on a literary search (assuming you or one of your men does the searching). If the search is well organized, your eight-hour investment should pay off in dividends of days or even weeks—cutting this much time off your project. On the other hand, if you find nothing helpful in the literature, you lose that one man-day but you have become reasonably sure that you are not wasting your company's money by duplicating someone else's design or development work. (The US Air Force balances reliability against weight in this manner, calling it "trade-off.")

Help Goes Begging

Is this literature research common practice? Unfortunately, no. At least, not according to the surveys, taken on the use of scientific information, that were presented at the International Conference on Scientific Information in 1958. The surveys pertaining to England were heavily documented and can be considered representative, so let's examine them.

One concerned reading habits of 1082 industrial technologists. (The term "technologist" here included all technical people—scientist, engineer and technician.) Average reading for the group was six periodicals scanned per year. Most information gained from reading was gained accidentally—not as a result of a search. Only 13% of the group ever deliberately searched literature. Most significant, 62% of the group didn't know of abstracts in their special fields. The survey concluded that these technologists did very little reading and few of them searched (though periodicals paid for by the reader stood more chance of being read thoroughly).

Another survey interviewed 157 engineers (called "applied scientists" in England). These men read quite a bit more—averaging four abstracts, reports, periodicals and textbooks each during a 14-day test period. However, two-thirds of all literature consultation was for news—to keep up to date. Only one-third was to search past literature. There was very little consultation of abstracts.

Then there was the survey of research scientists at the Atomic Energy Research Establishment in Harwell. Here, even among men oriented toward literature, most reading was of current periodicals—to keep abreast of latest developments. As a group, only 22% of the literature consultations were to find previously published material. Despite the fact that *Nuclear Science Abstracts* were widely dis-

tributed, and are the only method of notification of receipt of America's unclassified reports, only one-third of the scientists used them.

Newton Knew Better

Examining a number of these surveys, you see a clear pattern: Very few technical people go to the literature. Does the modern scientist or engineer consider himself less dependent on the works of others than did Newton who said: "If I have seen further than most men, it is by standing on the shoulders of giants."? Newton was willing to start where others left off, not from scratch. He read the available literature.

In contrast, J. D. Bernal, professor of physics at the University of London, comments on the fact that of 9100 periodicals available in the Science Library of London in a given year, 4300 were never consulted. Says Bernal: "Now it is difficult to believe that nothing of interest to the 87,000 readers at the Science Library was to be found in these 4300 periodicals. If so, the sooner they cease publication, the better."

Why don't engineers read more? Why don't they investigate technical literature for answers to their problems? For one thing, the sheer volume of technical literature is overwhelming–2 million articles published last year, and the rate per year is doubling every decade. Secondly, a lot of engineers don't like to read; besides, most of it is dull. Thirdly–and this is significant–some don't know how to go about searching literature. They've never been taught.

How to Hunt

Here's how a librarian might tackle a problem. An engineer requests an article he recalls reading some months ago on "Damage to products by molds or mildew." He's not sure which magazine it was in, but he does remember that he read it at his desk. He remembers neither author nor title.

The librarian decides to try searching among recently published articles; then if nothing turns up, he will go back a year or more. He subscribes to the current abstract-card service of *Engineering Index*, so he takes a quick look to see if "Molds" or "Mildew" are covered by the cards he receives. They are not. (Few libraries stock abstract cards of all subject areas covered by this index—however, the annual bound volumes includes all subject categories.)

Next, the librarian turns to *Applied Science and Technology Index*. The Apr 1960 issue shows nothing under "Molds" or "Mildew." But the March issue of this index is cumulative—it gathers together contents of the January through March indexes. Here, "Molds (botany)" shows nothing, but the enlarged index does contain a "see also" reference to "Fungi." Under "Fungi" the librarian finds a reference to an article, "Fungi Are Your Product Problem," published in PRODUCT ENGINEERING, Jan 18, '60. He notifies the engineer and lends him a copy of the magazine. The search took only minutes.

HERE'S WHERE TO LOOK

Most technical libraries will have some or all of these research tools (plus indexes of individual publications—usually annual):

APPLIED SCIENCE AND TECHNOLOGY INDEX—published monthly, with frequent cumulative issues and annual bound volumes.

BUSINESS PERIODICALS INDEX—a less technical companion of above index. Also published monthly, with frequent cumulative issues and annual bound volumes.

ENGINEERING INDEX—abstract-card service covering 1400 periodicals. Bound in annual volumes.

READER'S GUIDE TO PERIODICAL LITERATURE—periodicals of general nature. Cumulative and bound.

Had the librarian not found the article in the 1960 listings, he could have tried the 1959 bound volumes of both *Engineering Index* and *Applied Science and Technology Index*. If nothing turned up there, he could have examined the list of publications received by the engineer who requested the article. Then the librarian would check the annual indexes of each of the publications, and possibly inspect the table of contents of the more recent issues.

The example above shows one means of locating a specific periodical article. Subject searches are easier. The usual procedure is first to pinpoint the subject for which information is desired; then, by using proper reference tools, assemble a bibliography on that subject. Abstracts, which are short summaries of article content, may also be assembled. *Engineering Index* is particularly useful for this because it actually consists of abstract cards written by subject specialists. Translations of foreign language articles can be obtained from the index publisher.

Try It

Why not familiarize yourself with this little-used tool? After all, you're trained to solve problems in a logical manner–why treat literature in a hit-or-miss fashion, reading what comes along, then trusting to your memory when a problem arises.

EDITOR'S NOTE: Other recent articles dealing with the problem of finding appropriate technical literature:

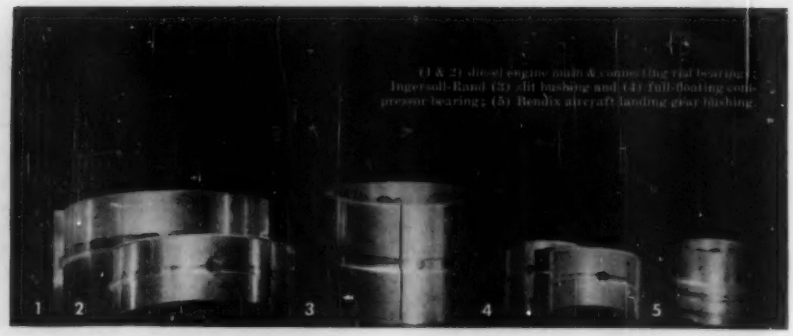
The Engineer's Bookshelf, Mar '57, p 167— A guide for building an engineering library. Suggests how to proceed and lists a technical bibliography (revised Mar 30 '59).

A System for Your Personal File, Apr 6 '59, p 43—Simple 2-step system for keeping tabs on any kind of subject matter, even if you forget title and author's name.

Knee-deep in Paper, Jan 12 '59, p 34—Discusses documentation methods used throughout Europe and in US.

More Service from Your Company Library, Oct 13 '58, p 72—How a small company library can do a good job with limited facilities.

Company Libraries Stretch R & D Funds, Oct 6 '58, p 30—Compares costs and effects of library research as against laboratory research.



for best results with

SOLID ALUMINUM BEARINGS

Sliding bearings offer inherent advantages of simplicity, economy and unlimited life. But—to minimize starting friction and prevent seizure—successful application depends on proper selection of materials and design characteristics. Aluminum bearings, now increasingly popular, are analyzed here.

D B WOOD, *manager, diesel engine section*
Aluminum Co of America

The desirable advantages of sliding bearings are counterbalanced by their normally high starting friction. This drawback—with its danger of seizure—has led to development of different materials with a variety of design characteristics. Among these materials are the helpful aluminum alloys.

But lower friction isn't the only consideration. When choosing the most suitable material, numerous complicating factors need attention. Some of these are: embeddability, compatibility, corrosion resistance, compressive and fatigue strength, coefficient of thermal expansion, cost and availability.

And sometimes these factors combat each other. For example, good embeddability requires the bearing material to have low hardness whereas good fatigue strength requires the reverse—high hardness. Therefore the chosen material must in some measure be a compromise.

What factors need careful consideration when weighing the advantages and disadvantages of solid aluminum for such bearings?

EMBEDDABILITY —ABILITY OF THE BEARING MATERIAL TO ABSORB DIRT OR METAL PARTICLES THAT ARE NOT WASHED OUT BY THE LUBRICANT

The degree of embeddability to be expected in a bearing material depends on its hardness and difference in hardness between the bearing and the shaft. Some of the softest bearing materials, such as babbitt metal, allow rapid penetration of the bearing surface by dirt. If excessive, this may be harmful because, as the bearing material loads up with dirt, its resistance to fatigue is reduced. Moreover, when its surface has become peppered with dirt, it begins to act as a lap on the shaft, causing abnormal wear. Bearing materials that are too hard, on the other hand, may cause excessive cutting and abrading of the shaft by dirt particles.

Aluminum bearing alloys strike a desirable medium between soft and hard bearing materials. They have a relatively high resistance to dirt penetration, allowing the oil to carry away most of the dirt caught in the filtration system. Yet they are soft enough to have a safe degree of embeddability.

COMPATIBILITY —THE ESSENTIAL PROPERTY THAT ALLOWS TWO METALS TO SLIDE AGAINST EACH OTHER WITHOUT WELDING OR SEIZING

Wear is a function of compatibility for bearing and shaft materials. At high speeds and under heavy loads, any two metals that are in contact will, in the absence of a lubricating film, seize or weld to some extent. A good bearing material, however, will resist this tendency to a much higher degree. Its effectiveness in this respect

TYPICAL MECHANICAL PROPERTIES OF CAST ALUMINUM BEARING ALLOYS

ALLOY AND TEMPER	750-T5	A750-T5	B750-T5	750-T5	A750-T5	B750-T5	X385-F
FORM	SAND CASTING			PERMANENT-MOLD CASTING			DIE-CASTING
Tensile Strength, psi	20,000	20,000	27,000	23,000	20,000	32,000	36,000
Tensile Yield Strength (Offset=0.2%), psi	11,000	11,000	22,000	11,000	11,000	23,000	20,000
Elongation, % in 2 inches	8.0	5.0	2.0	12.0	5.0	5.0	3.0
Compressive Yield Strength, (Offset=0.2%), psi	11,000	11,000	22,000	11,000	11,000	23,000	—
Brinell Hardness 500-kg load, 10-mm ball	45	45	65	45	45	70	—
Shearing Strength, psi	14,000	14,000	18,000	15,000	14,000	21,000	—
Endurance Limit, psi (R.R. Moore type specimen, 500,000,000 cycles)	—	—	10,000	9,000	9,000	11,000	—

EFFECTS OF COLD-WORKING 750-T5 PERMANENT-MOLD CASTING TO 750-T101 TEMPER

PROPERTY	DIRECTION OF TEST	750-T5	750-T101
Tensile Srength, psi	Axial	22,000	22,000
	Tangential	22,000	23,000
Tensile Yield Strength, (Offset 0.2%), psi	Axial	11,000	13,000
	Tangential	11,000	16,000
Compressive Yield Strength, (Offset 0.2%), psi	Axial	11,000	21,000
	Tangential	11,000	16,000
Brinell Hardness 500-kg load, 10-mm ball	—	45	50

COMPOSITIONS & AVAILABLE FORMS IN ALUMINUM ALLOYS

	COMPOSITION, % BY WT				
	750	A750	B750	X385	X8280
Tin	6.5	6.5	6.5	0.7	6.5
Copper	1.0	1.0	2.0	3.7	1.0
Nickel	1.0	0.5	1.2	—	0.5
Silicon	—	2.5	—	5.0	1.5
Magnesium	—	—	0.8	—	—
Cadmium	—	—	—	0.7	—
Lead	—	—	—	0.7	—

depends upon the mechanical, chemical and metallurgical properties of the metal as well as on nature of any lubricants.

All these factors are, to a large degree, evaluated and compensated for in the development of the bearing material. This leaves only the problem of proper application to the design engineer. Although each application must be weighed individually, there are guides for design:

• **Serious welding** can be avoided by rapid and adequate heat dispersal during momentary metal-to-metal contact on the running surface of a bearing. Because of the high thermal conductivity of aluminum, heat generated by a local high contact point or other causes can be quickly dispersed in a solid aluminum bearing.

• **Metal-to-metal contact** between a bearing and shaft or other rubbing surface can be caused by several factors, among them reduced oil clearance, dirt in oil, shaft misalignment, bearing misalignment or overloads.

• **Bearing temperature** can be controlled in three ways: (1) heat transfer through the bearing and housing; (2) rate of lubricant flow through the bearing; (3) temperature of the inlet oil.

• **An increase in shaft hardness** with proper finish usually reduces the amount of wear on the shaft during operation. Shaft hardness, however, also depends upon other considerations besides bearing requirements. In general, shaft hardness should be higher than solid aluminum bearing hardnesses listed in the table of properties.

THERMAL EXPANSION—EXCESSIVE EXPANSION MUST BE COMPENSATED FOR IN THE DESIGN

With an aluminum alloy bearing fixed in a ferrous housing, the resulting stress is increased as temperature rises from ambient to operating levels. Table (next page) shows coefficients of thermal expansion for aluminum-bearing alloys are about twice that for ferrous metals.

COMPARISON — THERMAL EXPANSION OF SELECTED MATERIALS

MATERIAL	TYPE	AVERAGE COEF. OF THERMAL EXPANSION PER DEG F (Based on unit of length at O F)			
		0 TO 100 F	0 TO 200 F	0 TO 300 F	0 TO 400 F
Aluminum	High purity	0.000,012,3	0.000,012,7	0.000,013,0	0.000,013,4
Aluminum	750 Alloy	0.000,012,2	0.000,012,7	0.000,013,0	0.000,013,3
Aluminum	A750 Alloy	0.000,011,9	0.000,012,3	0.000,012,6	0.000,012,9
Aluminum	B750 Alloy	0.000,012,1	0.000,012,5	0.000,012,9	0.000,013,3
Tin	"Pure"	0.000,012,6	0.000,012,9	0.000,013,1	0.000,013,3
Bronze	78 Cu-8 Sn-14 Pb	0.000,009,7	0.000,009,9	0.000,010,1	0.000,010,2
Steel	SAE 1045	0.000,006,0	0.000,006,3	0.000,006,6	0.000,006,8
Cast Iron	SAE 120	0.000,005,5	0.000,005,7	0.000,006,0	0.000,006,2

For this reason, when aluminum bearings are used in ferrous housings, and when interference fit must be maintained at room temperature, a limitation is placed on the operating temperature of the bearing. This limit depends on the aluminum alloy used, as shown in the table of properties.

If max operating temperatures are exceeded, the bearing may show loss of interference fit. The amount of initial interference fit at room temperature influences the degree of interference fit that remains after operation when the bearing has cooled down. Successful operation of the bearings may not be affected even though under certain conditions of operation some loss of interference fit may occur with solid aluminum bearings. In many cases, when the engine is idle, a certain amount of clearance between bearing and housing is permissible as long as the bearing is positively located, or held in place.

Interference fit will then be reestablished soon after the bearing has warmed up. With proper selection of initial interference fit, solid aluminum bearings, after operation within the max temperatures given in the table, will generally retain some degree of interference fit at room temperature.

WETTABILITY—OIL RETENTION AND WETTABILITY ARE A FUNCTION OF SURFACE HARDNESS AND FINISH

Recommended finish for the inside running surface of an aluminum bearing is between 16 and 25 microinches rms. Experience has shown it is more important to have an accurately machined surface, without drags or burnishing, than a low microinch rms finish.

Surface finishes of the housing bore and bearing back should preferably be smooth—about 45 microin rms max for the housing bore and 15 microin rms max for bearing back. These low figures are advisable because in operation the aluminum bearing tends to embed itself in the valleys of the bore left by the finishing operation, resulting in a decrease in initial stress.

The appearance of a bright, shiny surface can be misleading because in the process of obtaining it, the metal may have been burnished and peaks of the finish flattened down. Later, under load, these flattened peaks may release particles of bearing material and damage the bearing surface.

Full-floating bearings, because they rotate with the shaft, require less critical finish specifications for the bearing and housing surfaces.

Plating is not necessary for a large majority of solid aluminum bearing applications. There are few applications, such as heavy loads at very low speed, where plating may be used to advantage.

This plating can take the form of an electroplated babbitt deposit of 90% lead, 10% tin. Most plating companies in any fairly large city are familiar with and can perform this operation.

Solid aluminum bearings can operate successfully on hard or soft shafts, an advantage in keeping shaft costs low. Under identical conditions, hard shafts show less wear than soft ones, and this also can be an economic factor, depending on the expected useful life of the machine or the limit of part rejection set by wear. Under certain conditions, the combination of aluminum bearings with shaft of 300 Bhn and higher will give the max service life.

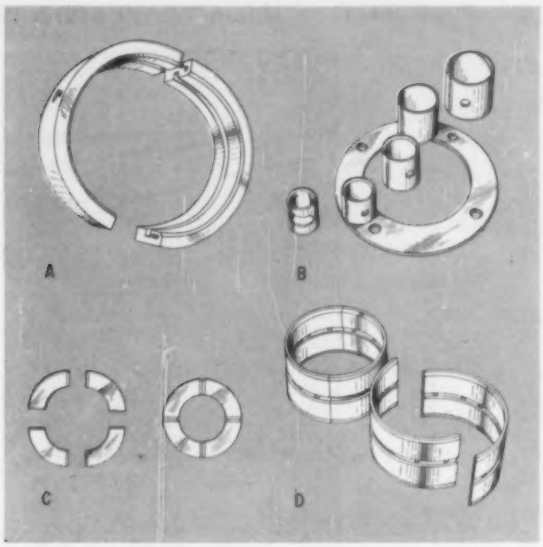
On the other hand, solid aluminum bearings give better results with soft shafts than any other bearing material. Aluminum bearings will not damage soft shafts if failure takes place (although the failed bearing can be difficult to remove from the shaft). In general, aluminum bearings can be used with almost any surface hardness of shaft, from 175 Bhn to 650 Bhn or higher.

The finish of the shaft, and the method by which the finish is obtained, should be controlled. A finish should always be obtained by grinding or turning, without loading or burnishing, so that a fine, clean surface results.

It has sometimes been found advisable, to first grind or turn to a very low microin rms and then to increase this rms by lapping. This method establishes a good, even plateau, into which lapping introduces valleys that serve to get wettability and better oil retention and to break up any adhesion tendencies. Shaft finishes of around 30 microin rms obtained by this method are adequate.

LIMIT FOR FIXED ALUMINUM BEARINGS IN FERROUS HOUSINGS

ALLOY	MAX. OPERATING TEMP., F
750-T5	200
750-T101	250
A750-T5	200
A750-T101	250
B750	300
X8280	300



TYPICAL ALUMINUM BEARINGS: (A) Two half-shells for fixed-bearing types; (B) Solid bushings and thrust washers for intermittent and light duty; (C) Four-segments bearing for easy assembly; (D) Full-floating bearing.

Advantages of Solid Aluminum Bearings

Very high load-carrying ability is characteristic of solid aluminum bearings—those of Alcoa alloy are operating in engines under unit loads of 10,000 psi on projected area. Many laboratory tests have been completed with thousands of hours of operation at 12,000-psi unit loading. With proper shaft preparation, lubrication and oil filtration, it should be possible to achieve even higher load limits.

For design purposes, average recommended unit loadings for solid aluminum bearings are as follows:

- Reciprocating load-pressure lubrication—5000 psi
- Unidirectional load-pressure lubrication—3000 psi
- Unidirectional load-doubtful lubrication—1000 psi.

These values should be used as a guide and revised because the many other elements of the machine may require higher or lower bearing loads. Aluminum bearings have run with *PV* (present times constant) valves ranging from 10,000 to 75,000.

Generally, bearing loading used for design purposes can be based on max load or average load, depending on application and conditions of operation. In either case, total load is divided by net projected area of a bearing half-shell. The result gives an approximation of the arc of bearing loading. This process will not give the exact arc because that will vary with configuration of the bearing and shaft, and the load application point.

When designing new engines, allowance can be made to take advantage of the improved performance and lower costs that aluminum bearings frequently offer. For example, the engine crankshaft can be stiffened by reducing the length of the bearing. This also provides space for additional balancing. Main bearing saddles can be reduced in length, thereby decreasing misalignment. This permits making the crankcase stronger without change in weight, and it reduces crankcase cost.

Very high speeds can be withstood by solid aluminum bearings. Successful tests have been conducted at surface speeds up to 275 ft/sec. Smaller dia bearings are used in production at speeds of 35,000 rpm. The much lighter weight of aluminum bearings results in lower centrifugal forces—in turn permitting higher speeds.

High speed by itself is not a limiting factor for aluminum bearings, but is usually accompanied by high temperatures. Recommended max operating temperatures for aluminum bearings are given in the table of properties.

Aluminum bearings have wide applications in engine crankshafts where peripheral velocities are approximately 40 ft/sec and loads are up to 10,000 psi. Such bearings are made with generous wall thickness in accordance with recommendations given below.

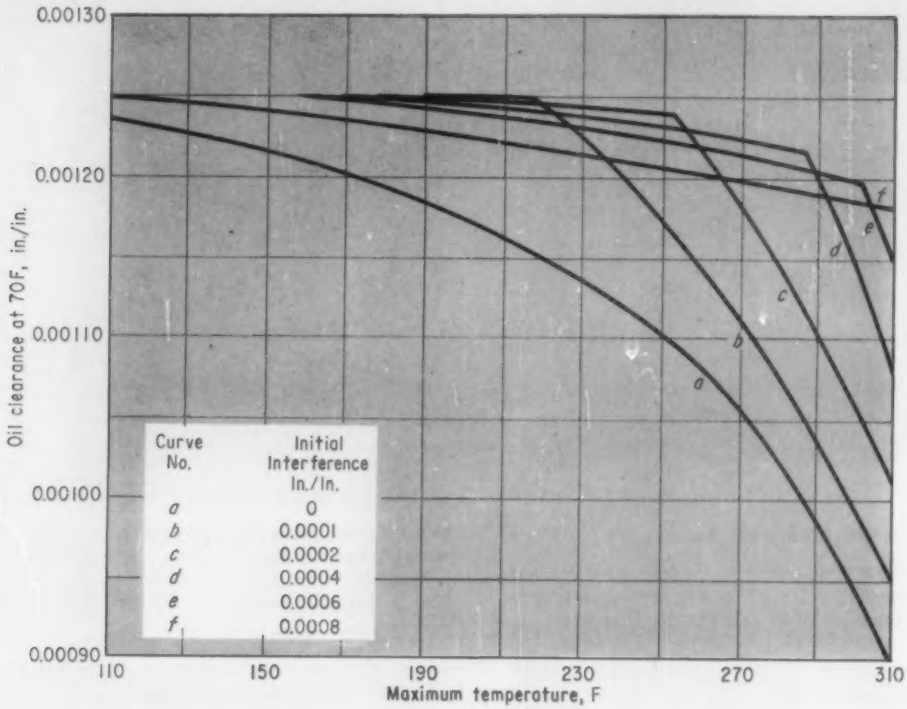
Long life and reliable performance of aluminum bearings can result from proper combinations of high loads and speeds. Air compressors with full-floating crankpin and main bearings have operated for 75,000 hours without appreciable wear. A minimum service life of 15,000-20,000 hours of operation appears common in diesel engines. For design purposes a service life of several thousand hours in engine operation at unit loads up to 4000 psi is a reasonable expectation.

In engines operating at max unit loads in the range of 2000 to 3000 psi aluminum bearings give several times the life attained by certain types of bearings lined with babbitt, copper-lead or cadmium alloy.

One interesting fact about aluminum bearing failure due to unexpected high temperatures is the aluminum paint coloring that appears in the lubricating oil. This warns of temperatures that can lead to shaft damage if permitted to continue. Timely correction of such conditions, when they arise, will permit improved bearing life and maintenance of aluminum bearings.

High resistance to corrosive agents in lubricants is another characteristic advantage of aluminum bearings, where formation of organic acids in the oxidation of lubricating oils is the problem with bearing material composed

Effect of Heat on Room-Temperature Clearance—B750-T5 Alloy



of lead or cadmium. This opens the possibility of using compound oils in engines where, previously, corrosion of bearings made it impractical to take advantage of the superior properties of such oils. Compounding to increase the lubricating qualities of the oils or to prevent accumulation of sludge deposits and ring sticking is made possible by the improved chemical stability of aluminum bearings. Laboratory tests have also indicated that aluminum has no catalytic effect on the oxidation of lubricating oils.

Misalignment must be carefully controlled in every machine. To compensate for it, a bearing material should have good conformability (not to be confused with compatibility, mentioned above). Conformability permits the shaft to flex within its natural configuration without interrupting the oil film and causing seizure.

Engine main bearing saddles are liable to some misalignment in relation to a fixed centerline. With solid aluminum bearings, ductility of the metal permits sufficient permanent deformation to distribute the load better and reduce unit loading.

In the laboratory, where testing apparatus was built in such a way that an unusually high edge loading was put on the main bearings, practically all types of bearings, except those of solid aluminum, failed before the test could be completed.

Designing Aluminum Bearings

Bearings are classified in many ways—by their function, design, method of lubrication or other characteristics. A distinction is made between bearing and bushing:

The term "bearing" designates two half-shells or several segments which form a whole.

The term "bushing" is used for single-piece hollow cylinders, which may have a single axial split.

Bearings and bushings can be further identified as fixed type, full floating and semifloating.

Fixed bearings are designed with an interference fit between the bearing back and the inside of the housing to prevent their rotation. This difference in dimension, which causes a compressive stress in the bearing, is also sometimes called "crush." Fixed bearings are used for low to moderate speeds with moderate to heavy loads.

Full-floating bearings rotate freely with the shaft—do not touch either the shaft or the housing while operating. They are for very high speeds and loads, and extremely high operating temperatures. The dual lubricated surfaces reduce the relative peripheral velocities with resultant lower operating temperatures.

Semifloating bearings have clearance on both sides—between bearing and housing and between bearing and shaft, as full-floating bearings do—but they do not rotate. They are held in position by a dowel or other means. They can be designed either to maintain the clearances throughout the operating temperature range or to make contact with either the shaft or the housing at certain temperatures. This type of bearing is used where external operating temperatures are the main factor—for example, in rolling mills.

Design Characteristics

Wall thickness for cast aluminum alloy engine bearings is preferably calculated empirically as follows:

$W_t = 0.04 \times$ Bearing OD $+ 0.020$ in.

In most cases with proper design a wall thickness below the values obtained by above formula can be used satisfactorily. The higher wall thickness values permit the bearing to be fixed to the housing properly.

When a dowel is used for endwise location and locking the bearing against rotation, a wall thickness of $\frac{1}{8}$ in. is considered to be the minimum (it allows for a circumferential oil groove, in registry with the dowel hole, which reduces the effective surface area at the dowel). When locking tangs of conventional type are used, the wall thickness should not be less than about 0.100 in. for bearings with high dynamic loads. The applicability of thinner bearings depends upon the severity of operating conditions.

Locking devices that provide max amount of resisting surface are desirable. Dowels and tangs are most popular and can be properly applied by maintaining recommended min wall thicknesses. Structural conditions that induce high stress concentrations should be avoided, particularly where oil transfer grooves are employed.

Grooves are of diminishing importance today. In the past they have taken many shapes, but present tendencies are toward simplified design. The choice of grooving depends mainly on method of lubrication. Multiple grooves can be used effectively for grease lubrication. Most diesel engines have a single-center circumferential oil groove or none at all. High load capacity of aluminum bearings permits narrow widths which insure proper flow of lubrication without grooves.

Oil clearance equivalent to 0.0015 in./in. of shaft dia is recommended for bearing of concentric bore or uniform wall thickness.

Stress concentration at the parting line of aluminum bearings sometimes requires eccentric walls to provide more clearance near the parting line. Where eccentric or taper-wall bearings are used, an oil clearance of 0.001,75 in./in. of shaft dia across the parting line face is used, with a clearance at right angles to the parting-line face of 0.001,25 in./in. of shaft dia.

Where grease is the lubricant, a clearance of 0.002 in./in. should be used.

Actually, many factors govern practical clearance, including finishes of the shaft, bearing and housing, type and degree of lubrication, amount and type of load, speed, average size of dirt particles and quantity in circulation. Clearance allowances for such factors are based on experience and cannot be reduced to firm recommendations.

Once proper clearances are selected for aluminum alloy bearings, there is very little change in oil clearance as temperature increases from room to operating level. The curves on facing page show this in spite of the fact that the coefficient of linear expansion is about twice that of iron or steel.

Bearing fit is another key factor in designing aluminum bearings. Where a full round bushing is used, the difference between the larger OD of the bushing and the smaller ID of the housing is called interference fit. The interference stress is obtained by multiplying the modulus of elasticity, 10^6 psi, by the interference fit in inches per inch of shaft diameter; or stress can be easily established by remembering that every 0.001 in. of interference per inch of bearing dia is equivalent to 10,000-psi stress in the bearing.

For full-round aluminum bushings, the following interference fits are recommended:

0.0004 to 0.0006 in./in. for alloys 750 and A750.

0.0006 to 0.0010 in./in. for alloys B750 and X8280.

Length-to-diameter ratio is an important factor in design of aluminum bearings because they can support and sustain very high loads, and thus offer the advantages of short bearing design. These advantages are:

- They permit shorter crankpins in engines.
- Webs can be increased (if the over-all engine size is not shortened), permitting stiffer shafts.
- Pin diameters can be reduced so that for a given housing ID a thicker bearing wall can be used.
- Oil film over a short bearing is easier to maintain.
- Tolerances and finishes are easier to maintain.

In many cases, therefore, it is best to limit the length of the bearing to an absolute minimum consistent with allowable bearing load. It is recommended that this ratio should be less than one for almost all applications of aluminum bearings.

The Various Aluminum Alloys

Three different alloys, 750, A750 and B750, are currently available in the form of castings produced by either sand casting or the permanent-mold casting process. Alloy X385 is used for die-cast parts. Alloy X8280 is produced in the form of sheet and plate. (The "X" prefix indicates these compositions may be subject to modification before being advanced to full commercial status.) Bearing castings of alloys 750 and A750 are supplied in the 15 temper or in the somewhat stronger T101 temper, attained by cold-working the castings as a final operation after heat treatment. This is usually accomplished by reducing the length of the casting in a hydraulic press by about 4%. This cold-working operation substantially increases the compressive yield strength and thereby improves ability of the bearing to maintain an interference fit through cycles of heating and cooling while installed in a housing of lower thermal expansion coefficient. At the same time, cold working of bearing alloys has very little influence on hardness.

Typical chemical and mechanical properties of various alloys are given in the tables on p 43; another table on the same page shows the effect of cold working.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, N. Y.

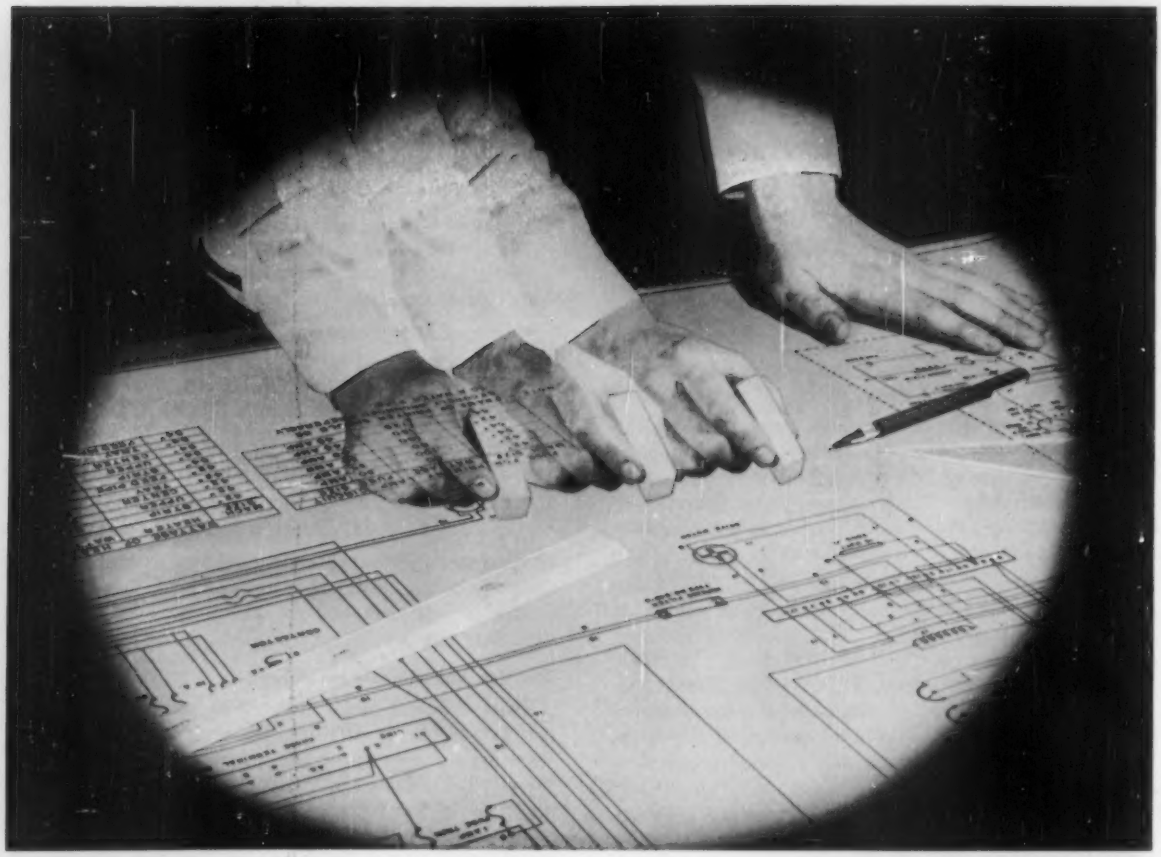
EDITOR'S NOTE: Additional information on sleeve bearings and materials will be found in:

Alloyed Plastics Give Oilless Bearings, May 25 '59, p 58—Describes a new type of impregnated-plastic bearing with relatively high load and low coefficient of friction.

A New Oilless Bearing Material, Jan '57, p 203—Describes characteristics, properties and limitations of full-density graphite-metal powder combinations.

Nylon-clad Sleeve Bearings, Mar 3 '58, p 52—Explains load and operational characteristics of nylon cladding for metal sleeve bearings.

Selecting the Right Journal Bearing Material, Sep '52, p 119—Gives comparative properties of white metal alloys, copper base alloys, silver, cast iron, graphite, and others.



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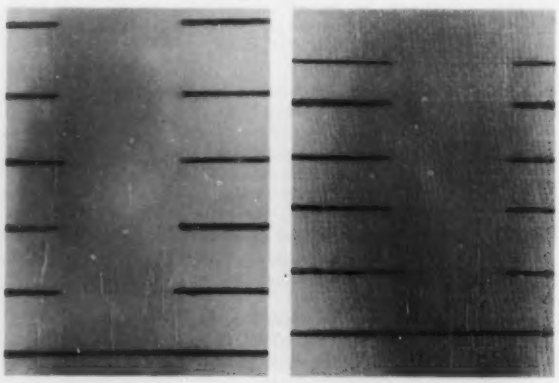
A good example of the consistent, balanced surface of CRONAFLEX is its superior *erasability*. CRONAFLEX not only erases easily and cleanly; it takes repeated erasing without ghosting or surface damage.

To prove it, make this simple test: draw a series of 6 lines horizontally on CRONAFLEX. Erase a vertical path through each line as you draw it, with a stroke long enough so that each succeeding line is drawn through another erasure. Now make the same test on the best grade of pencil cloth you have and compare the results. For more proof, reproduce each sample in a diazo machine and compare the prints.

Notice how cleanly and evenly CRONAFLEX (left) erases, without smudging or ghosting. Notice density and consistency of bottom line, drawn through 5 erasures! Compare same test made with good grade of pencil cloth (right). Bottom line drawn through erasure path is not uniform; erasures are uneven.



Superior covering power, cleanness of erasures and consistent line density—despite repeated erasing—are just a few of the reasons why CRONAFLEX gives you the best drafting surface you can use. For others, contact your local Du Pont Technical Representative or call your local Du Pont Photo Products Sales Office listed below. E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

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Atlanta 18, Ga., 1737 Ellsworth Dr. N. W.; Waltham 54, Mass., 45-4th Ave. (Boston), Chicago 46, Ill., 4560 Touhy Ave., Edgebrook Sta.; Cleveland 16, Ohio, 20575 Center Ridge Road; Dallas 7, Texas, 1628 Oak Lawn Ave.; Los Angeles 38, Calif., 7051 Santa Monica Blvd.; New York 11, N. Y., 248 W. 18th St.; Wynnewood, Pa., 308 E. Lancaster Ave. (Phila.). Export, Nemours Bldg., Wilmington 98, Del. In Canada: Du Pont of Canada Limited, Toronto.

For engineers who do occasional optical work without access to optical equipment, here's a simple method of finding "principal points" by

DETERMINING FOCAL LENGTH OF A THICK LENS

DONALD H CRONQUIST
Santa Clara, Calif.

Suppose you have a lens that needs exact optical measurement before you can use it. If it's an "ideal" thin lens, finding the focal length is easy, and you don't have to worry about "principal points." You assume that light bends in the center of the lens, then measure from center to object and center to image (distances S_1 and S_2 as shown in Fig 1).

Focal length is given by the equation $\frac{1}{f} = \frac{1}{S_1} + \frac{1}{S_2}$.

If both sides of the lens are in the same medium, such as air, focal length for each side is the same.

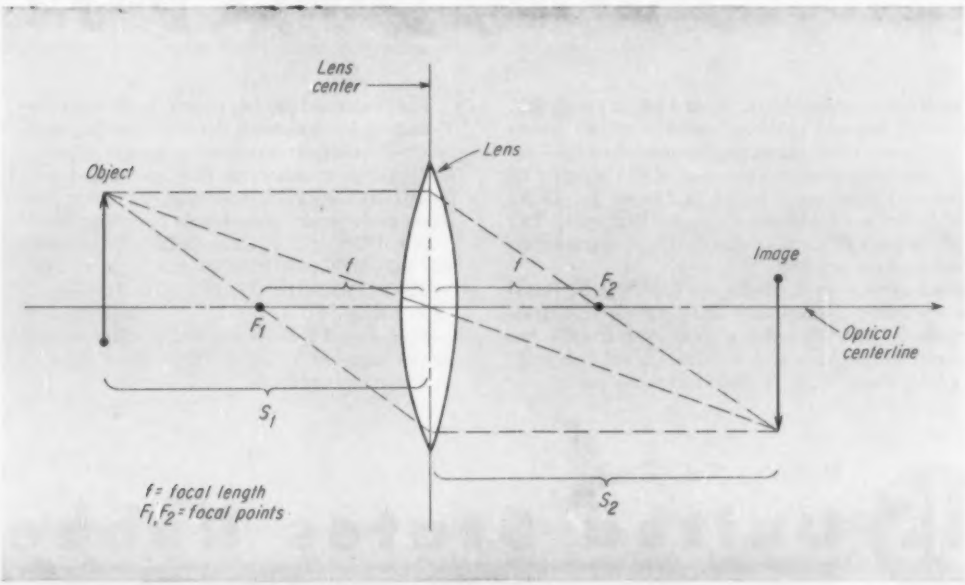
For a thick lens, however, it's not so simple. You can't assume that light bends at the center of the lens. It is considered to bend at points in planes perpendicular to the central axis, called principal planes. The intersections of these planes with the central axis are called principal points—(see Fig. 2).

Focal length of a thick lens is measured from focal point to corresponding principal point, so if you determine the focal length you can locate the principal point. Here's how to determine focal length:

Select an edge or mark on the lens or lens barrel for a reference point, then find focal point F_2 by focusing a source of light at infinite (or equivalent) distance on a white surface. Reverse the direction of the light through the lens and locate F_1. You now have distances A and B (Fig 3).

Focus an object, such as a lamp bulb with a single filament coil, onto a white surface so that both object and image are outside the nearby focal points and about equal distances from them. Measure distance of each

(Continued on page 51)



(1.) **THIN LENS.** Focal length is measured from center of lens.

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balanced driving power pays off

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It is estimated that each of the six C-105 U. S. Royal V-Belts on the motor-to-crankshaft drive travels a distance of approximately 120,000 miles a year. Yet despite the severe abrasive atmosphere and the "occasional jamming" that takes place, these "U. S." V-Belts last *many years.*

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DETERRING FOCAL LENGTH OF A THICK LENSE continued

from the reference point. Now you have C and D. As shown in Fig 3:

$$C - A = S_2 - f \quad (1)$$

$$D - B = S_1 - f \quad (2)$$

from lens equation:

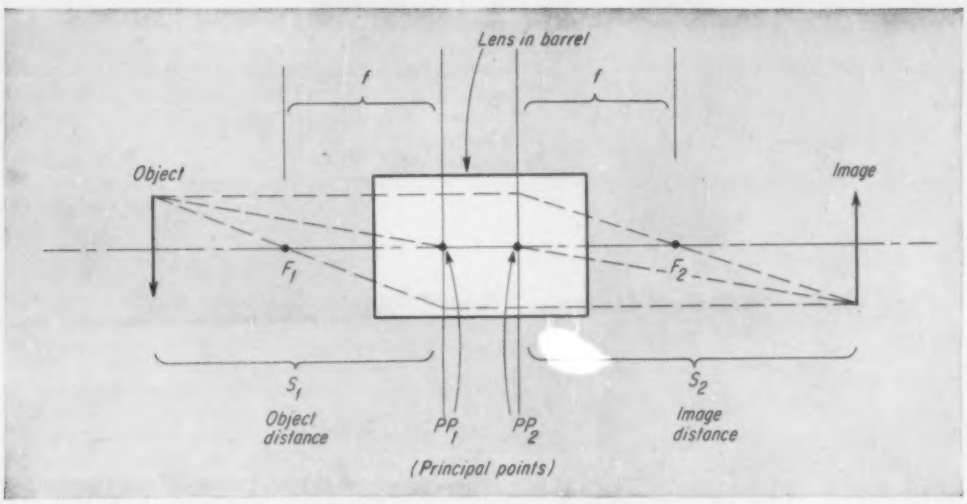
$$\frac{1}{f} = \frac{1}{S_1} + \frac{1}{S_2} \quad (3)$$

Therefore focal length of the lens is:

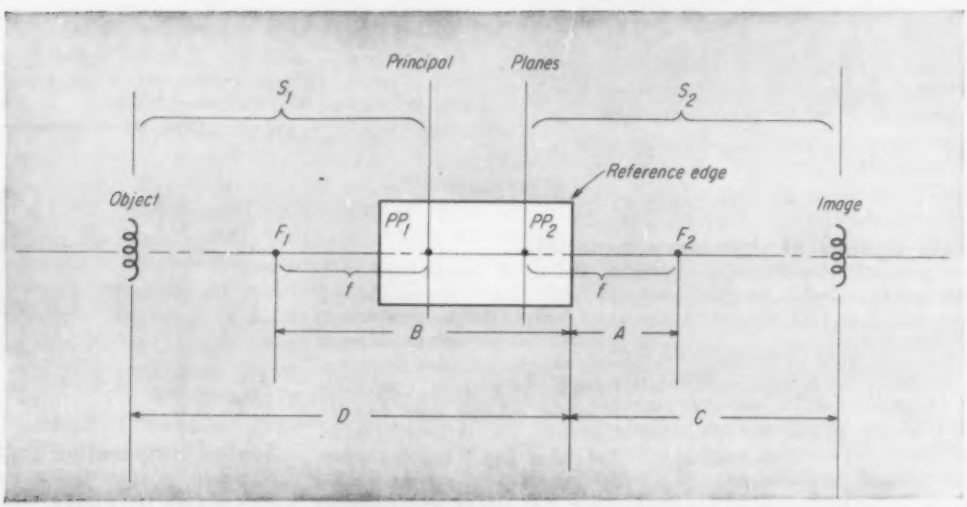
$$f = \sqrt{(C - A)(D - B)} \quad (4)$$

Principal point PP_2 is the focal length f from F_2; PP_1 is focal length f from F_1.

With principal points and focal length known, you can make accurate optical layouts and calculate accurate magnifications without interferences developing. Because principal points may be outside the lens, for close fitting parts serious interferences could result from a mislocated lens.

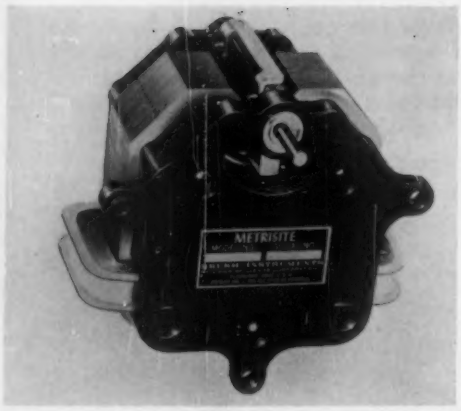


(2.) **THICK LENS.** Focal lengths are measured from principal points.



(3.) **REFERENCE POINTS AND SYMBOLS** used in calculations for finding focal length and principal points. Method consists of locating focal points, measuring distances from object and image to reference edge, then using formula.

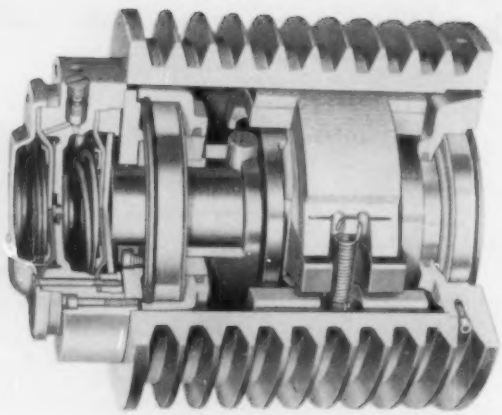
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Angular-motion transducer . . .

operates at 60 cps and converts angular motion up to ±40° to voltage, with linearity reported to better than 0.25%. Basic unit employs three-legged magnetic core with electrical coil around each of the legs. Identical secondary coils are connected in series opposition. Center leg has airgap in which lightweight, nonmagnetic armature moves. When ac input energizes center primary coil, magnetic field is set up in both loops of core, which, in turn, induces voltage in outer secondary coils. With armature at dead center, magnetic fields are symmetrical and induced voltages in secondary coils are equally opposed. Output is zero. Slightest movement of armature off center produces imbalance of two magnetic fields, which results in electrical output signal equal to difference in voltage between two secondary coils. Output is directly proportional to armature movement. Reactive force is about 9 milligram cm/degree. Scale factor of transducer is 0.57 v rms/degree. Null voltage is less than 0.1 v. Transducer measures 3 x 2⅜ x 1⅞ in. and weighs 20 oz. Priced at $115. Delivery from stock. **Brush Instruments, Div of Clevite Corp, 37th and Perkins, Cleveland 14.**

Circle 300 on Reader Service Card



Centrifugally operated clutch . . .

can be adjusted both for max torque transmitted and time delay in picking up driven load. Power requirements never exceed those of normal running load. Available in sizes from 3 to 2000 hp capacity, drive unit is said to eliminate need for oversize and special motors and starters. Triple-purpose accessory is reported to absorb starting and shock loads, providing smooth starts, gradual acceleration, and preventing damage to mechanism, since it can be set not to exceed predetermined torque transmission. Requires no lubrication, adjustment or maintenance for life of friction materials used (30,000 starting cycles). Models available for direct connection, V-belt or flat-belt drives. Can be supplied with integral brake drum or, since unit operates clockwise or counterclockwise, motor can be reversed to act as brake. Prices range from about $200 to $3000, depending on hp and rpm of motor. Delivery, approximately 8 wk. **Olme Precision Inc, 484 Masonic Bldg, Portsmouth, Ohio.**

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Large single crystals of refractory materials . . .

are now being produced by an arc-fusion crystal-growing process. Crystals are offered as cylinders in ¼ to 1 in. dia and lengths of a few inches to over 1 ft. Tungsten crystals ¾ in. dia x 12 in. long are being made. Larger crystals and other shapes can be made. Single crystals of tungsten are more ductile and can be worked or machined at much lower temperatures than presently available polycrystalline specimens produced by powder metallurgy or conventional arc melting. Single crystals of tungsten are suitable for use as electrical contact points in vacuum switches, lead-ins to vacuum equipment, and other applications where outgassing is a problem. Some of the non-metal crystals hold promise as semiconductors. Many of the metals and compounds of these large single crystals are available from stock. Cost of crystals depends upon diameter, length, quantity, and, in some instances, finish and shape. Special sample packages of metal and non-metal crystals are $90 each. **Linde Co, Div of Union Carbide Corp, 270 Park Ave, New York 17.**

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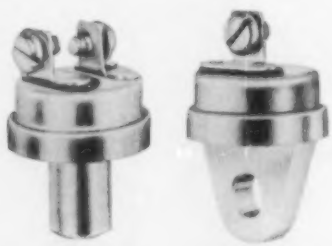
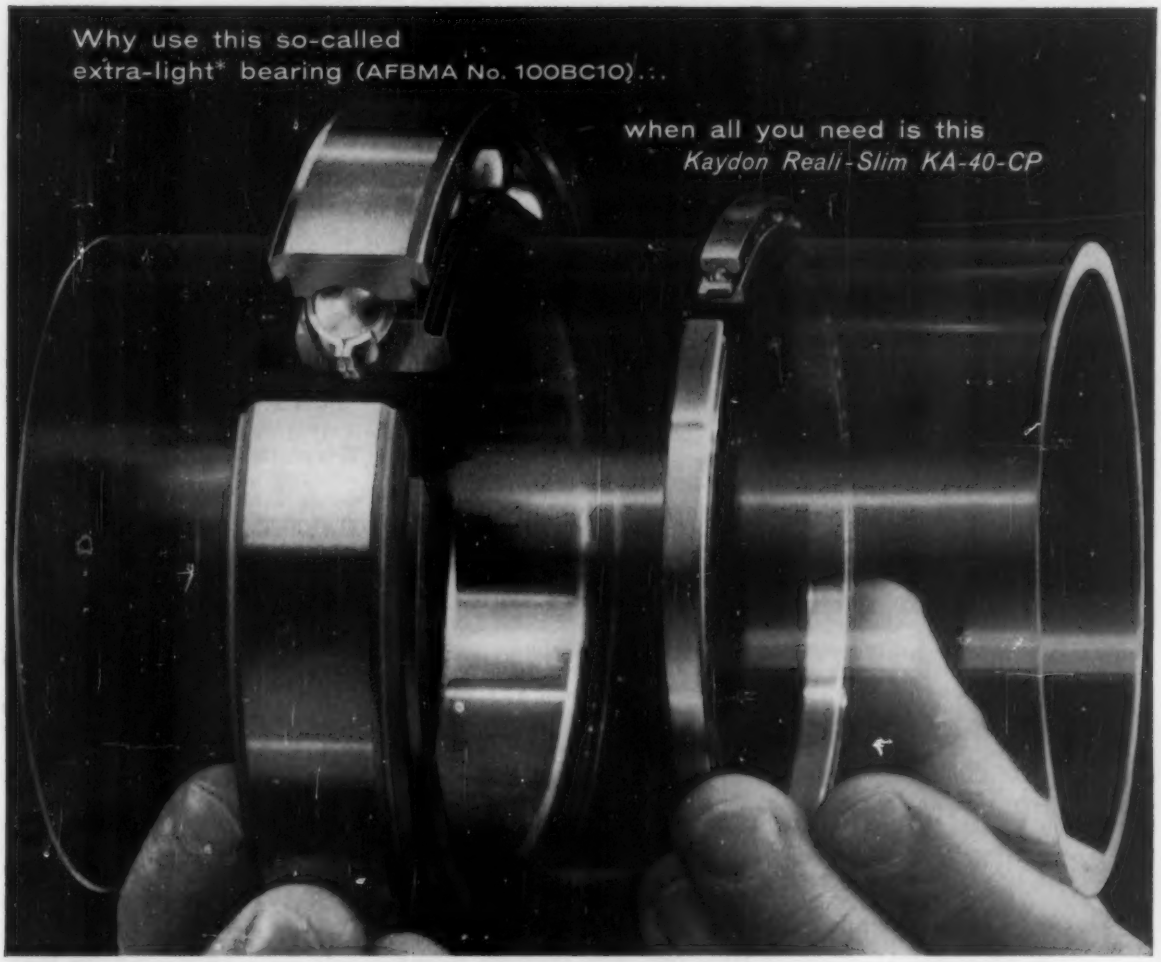


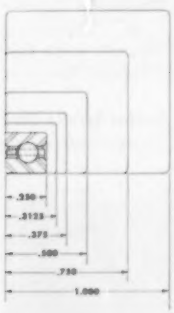
Sealed temperature control . . .

is said to be vibration resistant for use with engines, compressors, motor generator sets and similar equipment. Used as a high-limit or controlling thermostat, unit is identified as OM type. SPST, normally



News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

THE KAYDON ENGINEERING CORP.
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160

open or closed, device is rated 4 amp at 32 v, case grounded. Withstands 5 cps at 0.1 in. displacement up through 2000 cps at 20 g; ambient temperatures of —65 to 325 F. Temperature-setting range is —40 to 300 F, with min nominal differential of 20 F. Prices start at $1.25. Delivery 3 wk. **Therm-O-Stats Inc, PO Box 303, Chartley, Mass.**

Circle 303 on Reader Service Card

Packaged precision drives . . . include three dual-speed drives and a worm-gear drive. Operate with rotary components such as resolvers, synchros and potentiometers. Worm-gear drive uses 180:1 ratio, which allows direct dial reading of 1 min. of arc. Dual-speed drives include gear reducer that positions and indicates with accuracy said to be 6 min. of arc. Ratios are offered through 72:1 and ratios of 20:1 and 36:1 are available with vernier. Velocity ratio is 10:1, which can be increased by ganging modular units to 100:1 or 1000:1 with two or three units added. All models meet MIL-E-4970 requirements and withstand temperatures from —80 to 200 F and shock to 100 g. **Technology Instrument Corp, 531 Main St, Acton, Mass.**

Circle 304 on Reader Service Card

Miniature vane axial blower delivers 64 cfm at 0 in. sp and 3 in. sp at shutoff in two-pole version, with 37-w input and temperature rise of 104 F max. In four-pole design, at 11,000 rpm nominal, input is 8 w, 0.08 amp with low temperature rise of 59 F. Measures 1¼ in. long and 2 in. dia. Has ¼ in. OD and ⅛ in. ID. Blower operates at continuous duty in excess of 1000 hr at 257 F. **Eastern Air Devices Inc, 385 Central Ave, Dover, NH.**

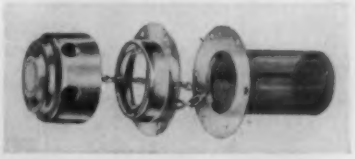
Circle 305 on Reader Service Card

Packless valve . . . for gas and liquid service where unfiltered conditions prevail has soft diaphragm, which is said to be unaffected by particles of dirt trapped against valve seat. Diaphragm is resilent, and when valve is opened and particles are washed away, diaphragm resumes original configuration. Rated for 500 psi and will close with 10 in.-lb torque at that pressure in dead-end service. Knurled-knob actuators are available. Furnished in brass with ⅛ or ¼ in. NPT connections. About $2.50 in small quantities. From stock. **Geo W Dahl Co Inc, 86 Tupelo St, Bristol, RI.**

Circle 306 on Reader Service Card

Miniature toggle switch and circuit-break combination . . . weighs less than 50 gram and has dielectric strength over 3500 v. Said to withstand up to 50-g shock. Device is reported to have interrupted circuits carrying up to 5000 amp at 120 v, 60 cps, successfully. Magnetic assist causes split-second tripping at heavy overloads, yet inherent thermal time delay is unaffected by transient overloads. When overload occurs, breaker trips and remains open until manually reset. If dangerous overload continues, contacts cannot be held closed, even manually. Available in ratings from 5 through 30 amp. $1.95 each on quantities over 1000. Delivery, 4 wk. **Wood Electric Corp, 244 Broad St, Lynn, Mass.**

Circle 307 on Reader Service Card



Filler cap with 30-mesh screen is for hydraulic fluid and oil reservoirs. Breather cap is of vented type, constructed of cadmium-plated steel, with twist locking action that fastens into flange. Brass wire screen is 3 in. deep and 1 1/16 in. dia. Assemblies are supplied with or without cap chain. **Lenz Co, Dayton 1, Ohio.**

Circle 308 on Reader Service Card

Silicon-bridge rectifier . . . is single-phase, full-wave power supply with operating range of —85 to 248 F. Unit is ⅞ x 1⅞ in. dia and is molded in epoxy resin. Has high surge-current rating of 35 amp, recurrent peak rating of 5 amp and peak inverse voltage of 200. Originally designed as power supply for rotary solenoids. **Ledex Inc, 123 Webster St, Dayton 2, Ohio.**

Circle 309 on Reader Service Card

Miniature electric brakes . . . and clutches are for equipment rated up to 1.5 in.-lb, which requires rotary drives that cycle automatically or by remote control. Dimensions are less than 1 in. dia and ⅞ in. long. Electromagnetic operating principle permits stepless torque modulation and operation from variety of actuating devices. Energized field transmits torque to armature through rotor or through friction face mounted directly to field, which is always stationary and requires no slip rings or brushes to supply current. Brakes or clutches operate directly from 28 or 90 v dc. Armature floats axially on separate hub. **Warner Electric Brake and Clutch Co, Beloit, Wis.**

Circle 310 on Reader Service Card

Graphitic tool steel . . . is said to be resistant to abrasive wear, galling, scuffing or scoring and to have excellent machinability because ¼ of carbon content is uniformly distributed as free graphite. Steel is AISI-SAE type 06. Can be heat-treated because steel is nondeforming and has broad hardening range: 1475 to 1550 F. Oil-quenching will give 63 to 66 Rc; cooling in still air about 30 to 35 Rc. Most tools are tempered at 300 to 450 F with about 62 Rc. Available as billets and bar stock. **Darwin & Milner Inc, 2222 Lakeside Ave, Cleveland 14.**

Circle 311 on Reader Service Card

High-temperature bolt . . . is said to be capable of 200,000 psi ultimate tensile strength at 900 F. It is also rated 260,000 psi min tensile at room temperature. Tensile, shear and fatigue strengths are reported to run 15 to 35% higher than those ratings of previous 900-F bolt-nut joints. Fastener combines 12-point external wrenching bolt with mating, self-locking nut. Nut is reported to have close tolerance on squareness of bearing surface to thread pitch diameter, held to 15 minutes through range of diameter sizes. Bolts and nuts are produced in diameter sizes No. 10 through ⅞ in., fine-thread series. **Standard Pressed Steel Co, Jenkintown, Penna.**

Circle 312 on Reader Service Card

Fin, fan-cooled speed reducer employs worm and gear reduction. Designed for horizontal right-angle drive with worm below, and is said to deliver up to 80% more capacity than comparable, non-

ventilated models of equal size. Reducer is available in range of sizes from 1.33 to 5.25 in. center distance. Horsepower ratings range from ⅓ to 18 hp. **Ohio Gear Co, 1400 E 179th St, Cleveland 10.**

Circle 313 on Reader Service Card

Reducing and relief valve . . .

for water, oil, air and gas service to initial pressures of 4000 psi is available in ¼- and ½-in. sizes. Single-seated, spring-loaded, diaphragm-actuated valve contains no external actuating connections or stuffing boxes. Adjustable pressure ranges are 0-1000, 0-2000, 0-3500 psi and pressures can be controlled within as little as 2 to 3 psi over entire adjustable pressure range. Body is heat-treated aluminum bar stock with bronze and Monel trim. **Atlas Valve Co, 20 South St, Newark, NJ.**

Circle 314 on Reader Service Card

Miniature gear reducers . . .

occupy less than 1 cu in. space and offer reduction ratios to 2 billion:1. Input starting torque is 0.002 in.-oz min. Class 1 or 2 ballbearing-mounted gears are used and friction slip clutches are incorporated where necessary. Typical specifications for size 11 unit are 100 in.-oz max load torque; 0.005 in.-oz starting torque; 0.02 gm-cm per cm, input-shaft moment of inertia; 30 minutes backlash at 5 in.-oz reversing torque. **Elgin Micronics, 366 Bluff City Blvd, Elgin, Ill.**

Circle 315 on Reader Service Card

Viton-to-metal bonded seals

are produced by bonding technique that results in seal that can be precision ground to seal against plane or conical surfaces. Seals can be used as poppets, swing checks, valve seats, flappers, pistons and other applications where axial movement is utilized to effect seal. **Stillman Rubber Co, 5811 Marilyn Ave, Culver City, Calif.**

Circle 316 on Reader Service Card

In-line relief valve . . .

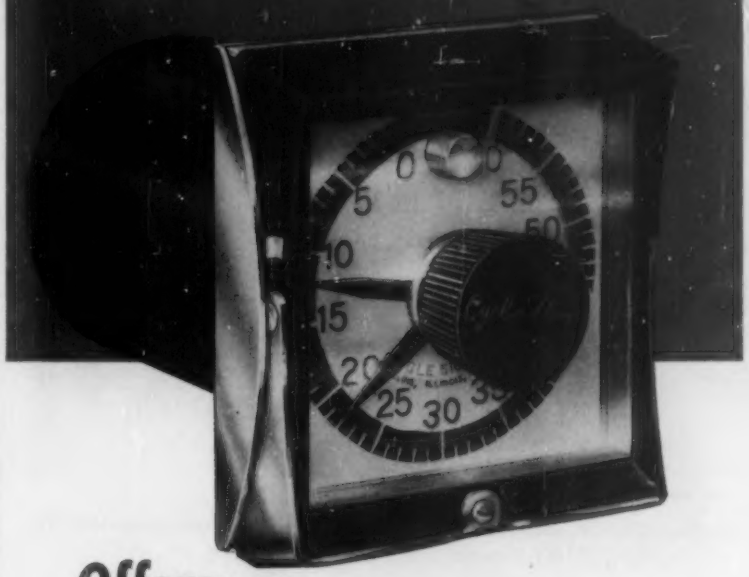
is for use in pressure systems where smooth, chatterproof operation is required,

continued on page 56

new *plug-in timer*

for controlling industrial processes

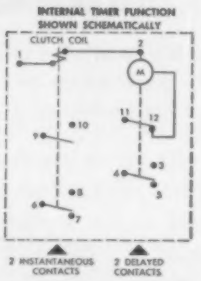
EAGLE'S HP5 CYCL-FLEX



Offers:

- *Fast, easy installation*
- *Quick change of time ranges*
- *Quick means of localizing trouble*

To Remove: Lift handle and pull out



With 4 switches — 2 switches operate instantly when timer is energized — 2 switches operate with time delay — delay time adjustable — selection of dials from 10 seconds to 60 hours. *Write Dept. PE-760.*

VISIT US AT THE

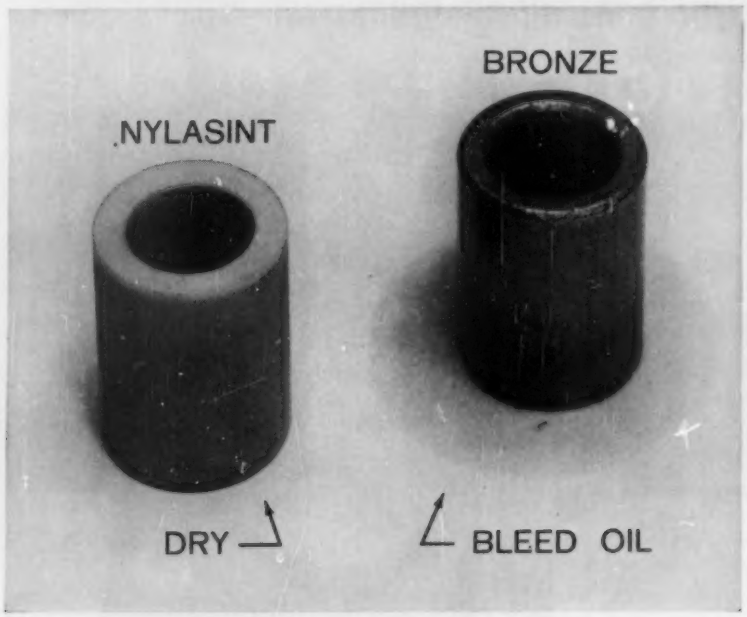
PRODUCTION ENGINEERING SHOW SEPT. 6-16 1960 NAVY PIER, CHICAGO BOOTH NO. 381

EAGLE SIGNAL COMPANY

Moline, Illinois

The Most Complete Line of Time-Count Controls

NYLASINT®. . . the only nylon with **permanent,** built-in oil lubrication



Even through wide temperature ranges and centrifugal speeds up to 1,000 Gs NYLASINT sintered nylon parts won't bleed.

Unlike oil-impregnated, sintered bronze which bleeds readily on paper (see above), NYLASINT holding up to twice as much oil is *permanently* lubricated to reduce friction, increase wear resistance and eliminate contact corrosion.

Inorganic additives also give resilient NYLASINT parts outstanding dimensional stability and high load capacity . . . important for such diverse fields as missile components and steel office furniture.

With NYLASINT you get all the prime advantages of nylon plus *extra* performance no other material offers in applications such as bearings, bushings, guides and washers.

For complete technical data on NYLASINT, call or write for new NYLASINT Bulletin BR-1111.

POLYPENCO® **INDUSTRIAL PLASTICS**

Halex Corporation

a subsidiary of The Polymer Corporation

Reading, Pa.

with zero leakage to within 95% of cracking pressure. Made of aluminum and stainless steel. Externally adjustable from 20 to 2000 psi and available from stock in ¼, ⅜ and ½ in. male pipe and male tube sizes. **Fisher Controls Inc, 1928 Lincoln Blvd, Santa Monica, Calif.**

Circle 317 on Reader Service Card

Subminiature elapsed-time indicator . . .

has digital readout that runs to 9999 hr, with numerals that are 5/32 in. high. Operates at 360 to 440 cps with 2½ w max power input. Features geartrain with 1.8 million:1 ratio and low-inertia motor. Meets MIL-E-5272B. Measure 1 1/16 in. OD and 2¾ in. max. Weighs 3¾ oz. Available in production quantities. **Waltham Precision Instrument Co, 221 Crescent St, Waltham 54, Mass.**

Circle 318 on Reader Service Card

Potentiometer pressure pickups

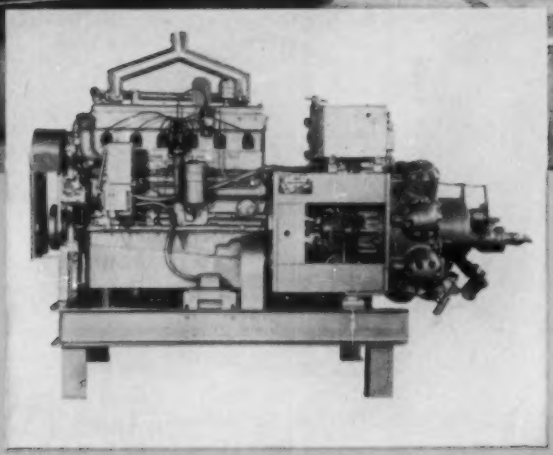
are available in full-scale ranges from 0 to 4 through 0 to 10,000 psi. In absolute- and differential-pressure service, ranges are available from 0 to 4 through 0 to 2000 psi. Helical bourdon tube is primary sensing element in all ranges exceeding 100 psi; NiSpan C diaphragm capsules are employed in ranges from 4 through 100 psi. Linearity for all ranges is within 0.3% of full range. Resolution is dependent upon range and desired resistance, but is always within 0.15% of range. **H E Sostman & Co, 347 E Lincoln Ave, Cranford, NJ.**

Circle 319 on Reader Service Card

Strain-gage pressure pickup . . .

is ¾ in. dia and ½ in. high. Weighs 8 grams. Unbonded strain-gage transducer is for use where accurate pressure measurements must be made under extreme conditions in min space. Pressure ranges are from 10 to 100 psia; 2 to 100 psig and ± 2 to ± 50 psid. Pressure limit is 1.5 times rated pressure without calibration shift and two times rated pressure without permanent damage. Operates without damage at temperatures from —320 to

continued on page 58



A typical Ready-Power air conditioning unit is in the Hillcrest Country Club, Mt. Clemens, Michigan, where an International-powered system cools the club house and heats the swimming pool. The U-450 engine uses natural gas fuel to drive the compressor supplying liquid freon to a 70-ton Ready-Power Water Chiller Package. Ready-Power reports universal customer satisfaction with International-powered air conditioning equipment.

Power package for air conditioning

READY-POWER'S 25-year experience proves INTERNATIONAL superiority on thousands of engine applications

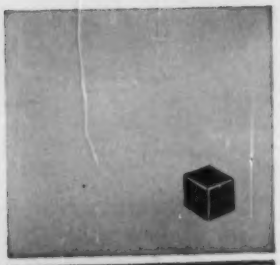
Here's another successful manufacturer reporting on the superiority of International engines. The Ready-Power Co., of Detroit has been designing and manufacturing engine-driven equipment for 36 years, has been an IH booster for 25 years. Ready-Power President H. D. Gumpper says, "Proven reliability of International engines plus excellent parts and service coverage, has led to the universal acceptance of Ready-Power engine generators and Ready-Power air conditioning equipment."

In 1935 Ready-Power introduced a line of International-powered electric plants, which now range in size from 5 to 200 KW. In 1945 came the Ready-Power line of International-powered air conditioning equipment. This experience of using thousands of IH engines proves that International power is best.

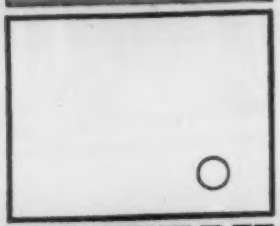
Your products, too, can benefit from the selling and engineering advantages of International design. Check the complete IH engine line—35 models from 16.8 to 385 max. hp—gasoline, LP gas, natural gas or diesel. Just call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL® ENGINES

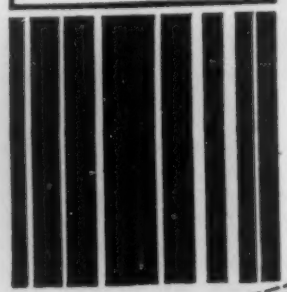
International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE



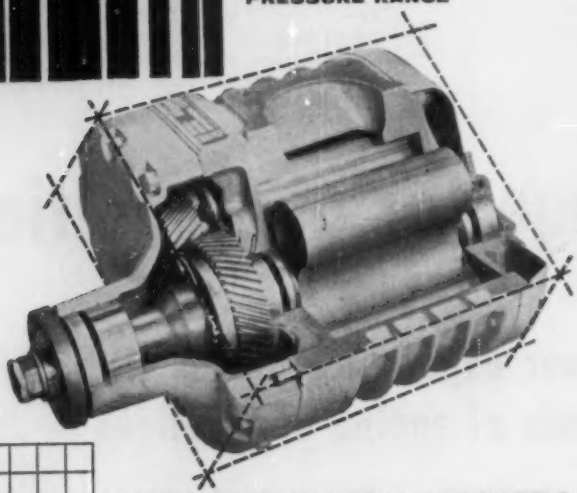
SMALLEST CUBE DIMENSIONS

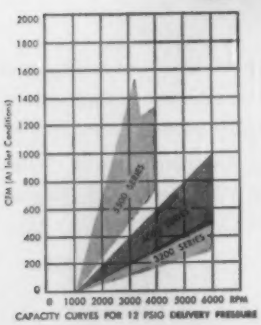


LIGHTEST WEIGHT



WIDEST PRESSURE RANGE





WITH M-D 3-LOBE BLOWERS

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

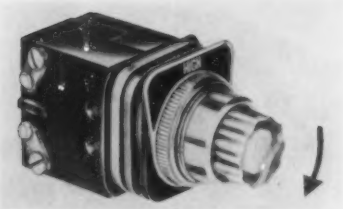
For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A Subsidiary of Mishle-Goss-Dexter, Inc.

300 F. Rated and max excitation are 5 and 12 rms. Carrier frequency is 0-20 kc. In operation, spring-type sensing element, with four active arms attached to force-summing diaphragm, provides electrical output proportional to pressure applied to it. Input resistance of four-arm bridge is 350 ohm. **Transducer Div, Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Calif.**

Circle 320 on Reader Service Card



Lighted oiltight pushbutton . . .

offers turn-to-test feature to determine if lamp is burned out. Six color caps are available. Unit is equipped with heavy-duty contacts for constant-service industrial applications. **Arrow-Hart & Hegeman Electric Co, Industrial Control Div, 103 Hawthorn St, Hartford 6, Conn.**

Circle 321 on Reader Service Card

Single-plane strain gage . . .

is said to have max sensing elements in given area, thus giving measurements closer to point than available with other single-plane rosettes. Available in ½- and ¼-in. sizes, in 45 and 60° configurations as well as on epoxy, paper or phenolic matrices. **Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, 42 4th Ave, Waltham 54, Mass.**

Circle 322 on Reader Service Card

Small-diameter solenoid . . .

lifts up to 8 oz intermittent or 6 oz continuous duty. Carries stroke up to $\frac{5}{8}$ in. push or pull type, as specified. Operates on 6 to 110 v dc with power requirements of 3 w continuous or 6 w intermittent duty. With plug-in or lead-type terminals. Size is ½ in. dia and 3½ in. long. **Guardian Electric Mfg Co, 1550 W Carroll Ave, Chicago 7.**

Circle 323 on Reader Service Card

Digital transducers . . .

measure pressure, flow, temperature and other variables and provide digital output in the form of contact closures for data recording or transmission. Units are

continued on page 59

completely mechanical and employ mechanical force amplifiers to drive shaft-position encoders from bourdon tubes, bellows, diaphragms or similar devices. Drive power for unit is obtained from small electric motor. **Datex Corp, 1307 S Myrtle Ave, Monrovia, Calif.**

Circle 324 on Reader Service Card

Size 8, 115 v servomotor . . .

has length of 0.840 in. and weighs 1.1 oz. Offers rotor inertia of 0.18 gm cm^2 coupled with stall torque of 0.22 in.-oz providing acceleration at stall of 86,500 rad/sec^2, which is said to be three times greater than equivalent units. Withstands ambient temperatures of −67 to 266 F. Max unit operating temperature is 392 F. **Helipot Div, Beckman Instruments Inc, 2500 Fullerton Rd, Fullerton, Calif.**

Circle 325 on Reader Service Card

Size 23 servomotor-generator

is for application as a rate servo and to provide damping in very-high-gain systems. Motor stall torques are available from 5.5 to 9 in.-oz with speeds of 9000 rpm at no load. Generator characteristics include 2.9 v per 1000 rpm and linearity of 0.2% to 3600 rpm. Available with plain or pinion shaft. **Kearfott Div, General Precision Inc, 1150 McBride Ave, Little Falls, NJ.**

Circle 326 on Reader Service Card

Electronic chassis slide . . .

offers interchangeability between left and right sides of cabinet. Has disconnect feature that permits pullout removal of faulty chassis from cabinet by pressing two buttons. Slide handles max loads of 300 lb. Utilizes 1½-in. stainless steel wheels, four per slide, instead of ballbearings. Dry-film lubricant is used on rails. Five chassis service positions are provided by positive-action tilt-lock. Can take up to 20 g shock load in closed position; 3 g in extended position. **Flotron Industries, 1608 Centinela Ave, Inglewood 3, Calif.**

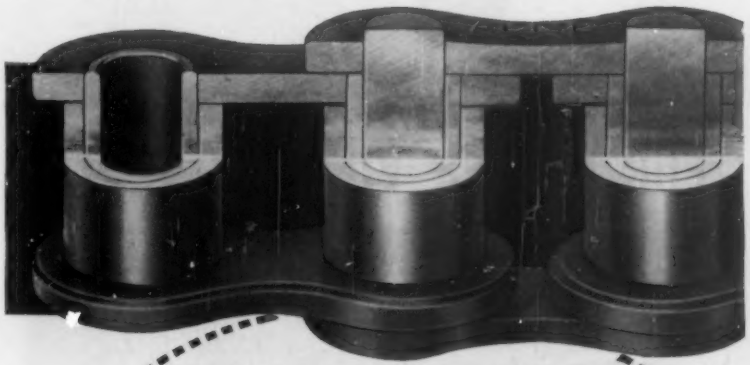
Circle 327 on Reader Service Card

Time-speed recorder . . .

monitors automated operations and provides split-second timing along with time-of-day information. Instrument aids detection of equipment malfunction by timing short-duration events to millisec accuracy, even at slow chart speeds. Time markings along edge of chart show time of day any event occurs while sweep of recording pen across chart displays dura-

continued on page 60

MAXIMUM
WEARING SURFACES
for longer chain life



ACME'S SECRET
for years of additional service

Special hardening of pins, bushings and rollers help insure maximum life expectancy of ACME Roller Chains. All parts subjective to articulation have glass-hard wear-resistant surfaces to render eminent life expectancy. The side plates or links which act as connecting members for articulating parts are specially heat treated and tempered to insure great strength and ductility.

Maximum hardening of all wearing surfaces on ACME Chains is conducive to longer life, resulting in greater economy and lower maintenance cost.

Your local distributor has a complete line of ACME Chains and Accessories on hand for immediate delivery. Call him.

Write Dept. I-O for new 100-page illustrated technical catalog including new engineering section showing 36 methods of chain adjustments.

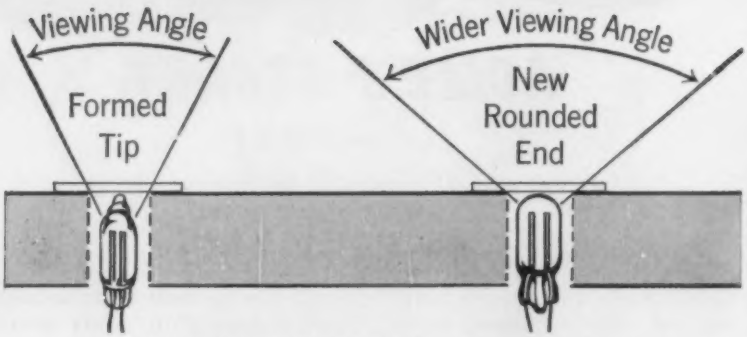
Acme Chain Corporation
HOLYOKE MASSACHUSETTS

COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS

NEW ROUND-END GENERAL ELECTRIC GLOW LAMPS

NE-2M for standard brightness
NE-2P for high brightness

FOR BETTER VIEWING... AND BETTER LOOKING INDICATORS!



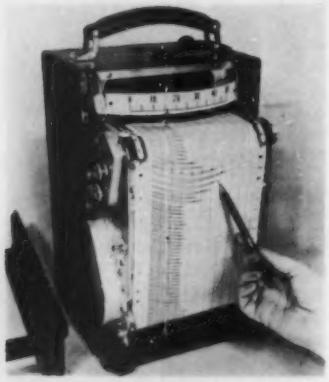
New shape of the Round End Glow Lamp brings its electrodes nearer to the end of the bulb—giving it a much wider viewing angle when flush mounted (see illustration above). And if the Round End Glow Lamp is placed beneath translucent material, the lighted area has a more uniform appearance.

The rounded end of clear-glass gives a distortion-free light when viewed end-on from any angle. Because of its smooth round end, this lamp can be used as a protruding element, thus improving the appearance of the panel.

New General Electric NE-2M and NE-2P Glow Lamps are more thoroughly described in the engineering data sheet, #3-9289. For your free copy, write: General Electric Co., Miniature Lamp Department M-023, Nela Park, Cleveland 12, Ohio.

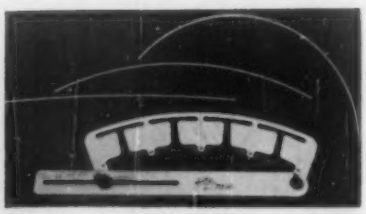
Progress Is Our Most Important Product

GENERAL ELECTRIC



tion of event. Timing is accomplished by closing or opening electrical control circuit. Standard chart speeds of ¾, 1½, 3, 6 and 12 in. per hr and per min. are provided. Sweep time scale ranges of 1 sec to 1 hr are available. Recorder operates on 115 v, 60 cps. Price is $975, complete with accessories, FOB Indianapolis. **R B Annis Co, 1101 N Delaware St, Indianapolis 2.**

Circle 328 on Reader Service Card



Arc ruler . . .

is used to draw arcs of circles of any radius from 7 to 200 in. or even more if center point of circle is beyond edge of drawing surface. Eliminates need for french curves, ships curves, splines and weights in drawing arcs. Movable pointer on scale reads radius length directly and gives exact arc required. Chart is provided to convert radius readings to civil engineer's scales. Ruling edge is 12 in. **Fullerton Engineering Sales Co, 4623 York Blvd, Los Angeles 41.**

Circle 329 on Reader Service Card

Stick construction kit . . .

consists of colored wood sticks and rubber joints, which can be combined to form infinite number of shapes and structures. Sticks slip into rubber joints to form rigid structures. Joints are either universal or T types. Suitable for mock-ups. 230-piece kit is $3; 370-piece kit is $5; 452-piece kit is $7. **Edmund Scientific Co, Barrington, NJ.**

Circle 330 on Reader Service Card

Wherever in the world your industrial machinery operates...

Shell Alvania Grease is there

Other outstanding Shell Industrial Lubricants available world-wide

- **Shell Tellus Oils** – for hydraulic systems
- **Shell Talona R Oil 40** – anti-wear crankcase oil for diesel locomotives
- **Shell Rimula Oils** – for heavy-duty diesel engines
- **Shell Turbo Oils** – for utility, industrial and marine turbines
- **Shell Dromus Oils** – soluble cutting oils for high-production metalworking
- **Shell Macoma Oils** – for extreme pressure industrial gear lubrication
- **Shell Voluta Oils** – for high-speed quenching with maximum stability

AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the Alvania beanii.

Around the world, Shell Alvania Grease is available—under the same brand name and providing the same outstanding lubrication. This is assurance that your customers abroad will enjoy the same performance from your equipment that domestic customers rely upon.

Alvania® Grease offers these performance-proved advantages: (1) It provides safe lubrication at both high and low temperatures. (2) It won't wash out even in locations where water splashing can't be avoided. (3) It has built-in protection against rust and pitting of anti-friction bearings. And because this *one* multi-purpose grease is specially designed to satisfy as much as 90% of industrial grease needs, less servicing time is required; inventory costs are less; and there is less risk of misapplication.

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TYPICAL EXAMPLE

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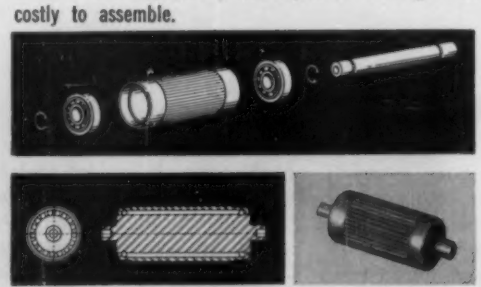

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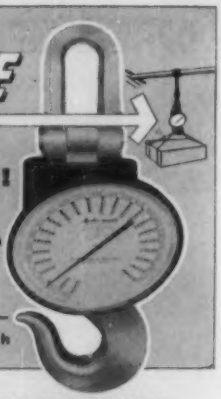

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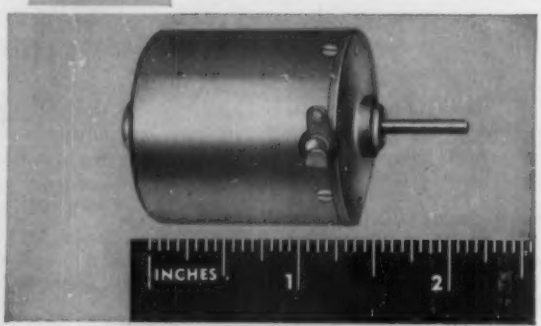

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DESIGN LITERATURE

Magnesium and Its Alloys

C SHELDON ROBERTS. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 10 x 7, 230 pp. $9.

A concise up-to-date reference book on the over-all aspects of magnesium and its alloys. Unusual for a reference book, it avoids tiresome repetition of commercial literature and datings of historical events. Metallography of Mg (not significant in design) is also omitted.

Because of its straightforward presentation, this book has a high percentage of useful information.

Engineering Thermodynamics

JAMES B JONES and GEORGE A HAWKINS. John Wiley & Sons Inc, 440 Fourth Ave, New York 17. 6 x 9½, 724 pp. $8.50.

This textbook is for use in undergraduate engineering courses in thermodynamics to help students to understand the first and second laws of thermodynamics, and develop some competence in applying these principles to engineering systems. There are abundant explanations for various points that are known to be stumbling blocks for students. The amount of explanation is decreased as the book progresses and the reader gains familiarity with the subject.

Principles of Guided Missile Design

JOSEPH J JERGER. D Van Nostrand Co Inc, Princeton, NJ. 6 x 9, 625 pp. $14.75.

This is the unifying volume (full title: "Principles of Guided Missile Design, System Preliminary Design") of the "Principles of Guided Missile Design" series and covers, at length, the interrelationships that exist in preliminary systems design. Much useful data from important branches of engineering and science involved in missile design is summarized in convenient working form.

A systematic mathematical approach to the problem of preliminary design of systems is introduced and its use illustrated via application to the preliminary design of a homing surface-to-air missile. All variables are expressed in mathematical form to obtain a solution to the resulting equations. This procedure leads to a solution of the problem with a significant savings of time, and presents a clearer perspective of the problem, which is of great value during formative or proposed stages of design.

Basic Ultrasonics

CYRUS GLICKSTEIN. John F Rider Inc, 116 W 14th St, NYC. 6 x 9, 144 pp. $3.50.

This introduction-type book bridges gap between layman's knowledge and a scientific treatise. First section gives general theory of ultrasonics with special reference to the nature of sound and ultrasound waves. The second section covers basic types of ultrasonic equipment, and an elementary knowledge of electronics on the part of readers is assumed. The third part describes in detail the most important ultrasonic applications.

ABSTRACTS FROM THE LITERATURE

Which Type Pump Casing?

Brief review of the differences between types of pump casings shows the factors influencing a designer's choice.

"Which Type Pump Casing is Best?" Power and Fluids, Vol No 2, Winter issue, Worthington Corp, Harrison, NJ.

Fluid Tightness

The requirements of each method for achieving fluid tightness in aircraft structure are described.

The several generally used design advantages and limitations are discussed.

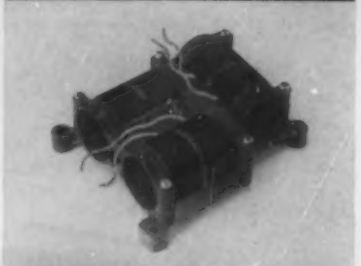
"Design for Fluid Tightness," R. C. Hempstead, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. Society of Aircraft Materials and Process Engineers, PO Box 39632, Griffith Sta, Los Angeles 39.

Long-time Performance from Short-time Burst Strength

Reports on investigation to develop a method of estimating long-time strength of thermoplastic pipe by means of short-time burst strength tests. The parameter developed was

continued on page 65

Electrofilm



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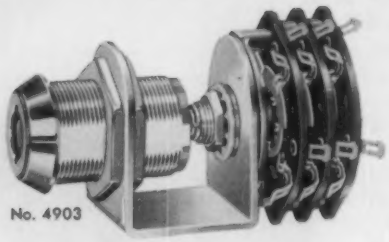

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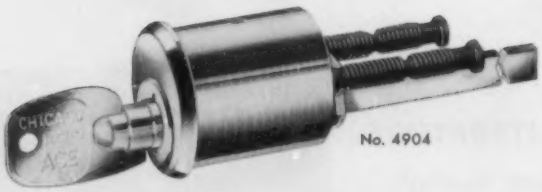

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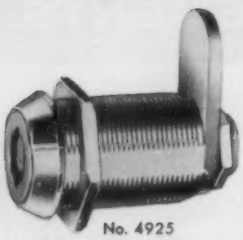

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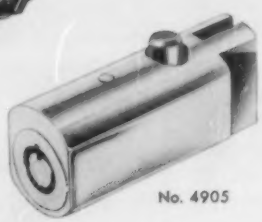

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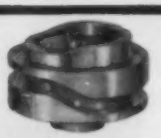

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found to be applicable to all types of plastics.

"Estimation of Long-time Performance of Extruded Plastic Pipe from Short-time Burst Strength," S. Goldfein, Materials Branch, USAERDL, Fort Belvoir, Va; Modern Plastics, May 1960, 575 Madison Ave, New York 22.

Applying Nondestructive Test Standards

Discusses how nondestructive testing and the standards on which it is based can be applied to improve both component and product quality and reliability.

"Applying Nondestructive Test Standards to Improve Product Quality and Reliability," George W. McDermott, Delco-Remy Div; General Motors Engineering Journal, April-May-June 1960, Technical Center, Warren, Mich.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

AC MOTORS—Catalog 200, 56 pp. Includes information on pricing and dimensions of shielded motors, from ¼ to 200 hp, and modifications. One section deals with motor selection and application. Sterling Electric Motors Inc, 5401 Telegraph Rd, Los Angeles 22.

Circle 350 on Reader Service Card

ALUMINUM BOXES AND COVERS—Catalog B60, 24 pp. Lists over 12,000 standard deep-drawn aluminum boxes and covers available from stock. Zero Mfg Co, 1121 Chestnut St, Burbank, Calif.

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METALS AND ALLOYS—Bulletins TIB-573, TIB-572, TIB-601, SIB-571; 4 pp. 8 pp, 10 pp, 12 pp, respectively. Bulletins cover properties, nominal composition, availability and application of thorium, calcium, high-purity magnesium and magnesium and aluminum casting alloys. Dominion Magnesium Ltd, Suite 1505, 320 Bay St, Toronto, Canada.

Circle 352 on Reader Service Card

SOLID-STATE TIMING MODULES—Bulletin 5906, 16 pp. Covers circuit design, manufacturing and assembly process, standard and special type specifications, sizes, mounting arrangements, weights and terminal styles. Tempo Instrument Inc, PO Box 338, Hicksville, NY.

Circle 353 on Reader Service Card

DRY BATTERIES—Brochure C-1, 22 pp. Specifications and descriptions of various types of available dry batteries. Includes cross-reference of comparative and interchangeable numbers for battery types. Marathon Battery Co, Wausau, Wis.

Circle 354 on Reader Service Card

VARIABLE-SPEED DRIVES – Folder 2874, 6 pp. Describes features of new drives. Illustrates types of assemblies and sizes available, speed-variation ratios and selection data. Link-Belt Co, Dept PR, Prudential Plaza, Chicago 1.

Circle 355 on Reader Service Card

LUBRICATING EQUIPMENT – Condensed catalog X-135, 8 pp. Lists variety of lubricating equipment for multitude of oiling jobs. With drawings, specification tables and descriptions. Oil-Rite Corp, 2382 Waldo Blvd, Manitowoc, Wis.

Circle 356 on Reader Service Card

MOTOR SELECTOR – Brochure L-1661A, 8 pp. Covers characteristics, ratings and specifications of motor and generator lines available. Howell Electric Motors Co, Howell, Mich.

Circle 357 on Reader Service Card

REINFORCED PLASTICS—Brochure, 8 pp. Describes services and facilities in field of reinforced-plastics manufacture. Illustrates typical products and three plants. Chart lists typical physical properties of polyester and epoxy resins used in combination with reinforcement materials. Atkins & Merrill Inc, Reinforced Plastics Div, Barlett St, Marlboro, Mass.

Circle 358 on Reader Service Card

HYDRAULIC COMPONENTS—Bulletin 146-F, 6 pp. Reviews ratings and operating characteristics of components for hydraulic systems up to 5000 psi. General specifications and photos of typical models are included. Denison Engineering Div, American Brake Shoe Co, 1160 Dublin Rd, Columbus, Ohio.

Circle 359 on Reader Service Card

SMALL IMPULSE COUNTERS—Brochure, 6 pp. Operating information, electrical ratings, types, weights and dimensions of three-, four-, five- and six-digit manual or remote electrical reset type of small electric impulse counters. Landis & Gyr Inc, 45 W 45th St, New York 36.

Circle 360 on Reader Service Card

PARALLEL, V-RIBBED BELT DRIVES—Booklet A2343, 4 pp. Outlines specifications of drives, illustrates operational advantages of belt design, gives hp ratings and lists sheave groove dimensions. Dayton Industrial Products Co, 2001 Janice Ave, Melrose Park, Ill.

Circle 361 on Reader Service Card

ADJUSTABLE INDUSTRIAL CLOSURES—Bulletin, 4 pp, and price list. Descriptions and dimensions of cam-action and lever-handle closures. With new price list for types S, T and H adjustable closures. Moeller Mfg Co Inc, Racine, Wis.

Circle 362 on Reader Service Card

BEADED CHAIN AND SMALL SWAGED PARTS—Folder, 4 pp. Describes and gives sizes, metals, finishes and lengths of standard hollow beaded chain and special beaded chain, with sections on special swaged parts. Auto-Swage Products Inc, Canal St, Shelton, Conn.

Circle 363 on Reader Service Card

HEAT-REACTIVE TUBING—Bulletin, 4 pp. Properties, characteristics and dimensions of flexible, heat-reducible tubing. Irvington Div, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6.

Circle 364 on Reader Service Card

ALLOYS—Bulletin, 8 pp. Discusses properties of each alloy suitable for electrical and electronics industry use. Typical applications are given for each alloy. Riverside-Alloy Metal Div, H K Porter Co Inc, Riverside, NJ.

Circle 365 on Reader Service Card

TOOL STEEL FOR COLD-HEADING—Pamphlet, 8 pp. Describes water-hardening vanadium-alloy tool steel, with information on forging, stress relieving, hardening, tempering and annealing. Uddeholm Co of America Inc, 155 E 44th St, New York 17.

Circle 366 on Reader Service Card

HIGH-TEMPERATURE URETHANE FOAMS—Data sheets CPP 14 and 13, 3 pp each. Properties and applications of high-temperature-resistant urethane foams. No. 14 describes fast-acting foam; No. 13 covers foam with long pot life. Carwin Co, North Haven, Conn.

Circle 367 on Reader Service Card

ROTARY GEAR PUMP—Bulletin G-3, 6 pp. Describes line of internal- and external-bearing type pumps to handle lubricating and nonlubricating materials in viscosities up to 5 million SSU. Sier-Bath Gear & Pump Co Inc, 9252 Hudson Blvd, N Bergen, NJ.

Circle 368 on Reader Service Card

ABSOLUTE-PRESSURE AND GAS-DENSITY SWITCHES—3 data sheets, 2 pp each. Typical applications, dimensional drawings, specifications and characteristics for two absolute-air-pressure switches and one gas-density switch. Newark Controls Co, 15 Ward St, Bloomfield, NJ.

Circle 369 on Reader Service Card

SLIDING-GATE PRESSURE REGULATORS—Catalog J160-1, 8 pp. Describes self-operated, pilot-operated, solenoid-op-

continued on page 66

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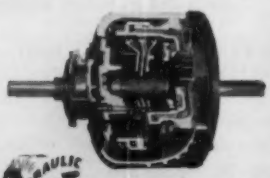

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DESIGN LITERATURE.....continued

erated and back-pressure regulators and applications of each type. Covers operation of each. Presents features, cutaway drawings, sizing charts, flow curve, sample specifications. OPW-Jordan, 6013 Wiehe Rd, Cincinnati 13.

Circle 370 on Reader Service Card

ADJUSTABLE TIME DELAYS—Technical publication 80, 4 pp. Specifications, dimensional drawings and typical curves for transistor-equipped units covering time delays from 0.1 to 300 sec. G-V Controls Inc, 101 Okner Parkway, Livingston, NJ.

Circle 371 on Reader Service Card

FLUSH-MOUNTING LEGEND LIGHT—Catalog sheet, 1 p. Describes legend light for airborne or ground-support applications. Includes dimensions of lens and general specifications. Radar Relay Inc, 2322 Michigan Ave, Santa Monica, Calif.

Circle 372 on Reader Service Card

THERMOSETTING MATERIALS—Comparative chart, 2 pp. Shows mechanical, electrical and thermal properties of all general-purpose thermoset materials. Fiberite Corp, Winona, Minn.

Circle 373 on Reader Service Card

HEAT-TRANSFER OIL—Bulletin, 2 pp. Covers properties, advantages and applications of heat-transfer oil for use in closed circulating systems equipped with expansion tanks. Sun Oil Co, Industrial Products Dept, 1608 Walnut St, Philadelphia 3.

Circle 374 on Reader Service Card

TAB-INDICATOR TOGGLE-SWITCH ASSEMBLIES—Data sheet 174, 2 pp. Describes ratings, toggle-lever positions, contact arrangement and models available. Micro Switch, Freeport, Ill.

Circle 375 on Reader Service Card

MINIATURE INSULATED THERMOSTATS—Catalog sheet, 2 pp. Describes series of insulated thermostats that are identical to miniature grounded-case models, except that 4-80 adjustment screw has been replaced with insulated 2-56 adjustment screw and solder-tab assembly. Price list is attached. Chatham Controls Corp, 33 River Rd, Chatham, NJ.

Circle 376 on Reader Service Card

PANEL INSTRUMENTS FOR COMMERCIAL USES—Bulletin 25-560, 2 pp. Specifications and dimensions of microammeters, milliammeters, ammeters and voltmeters in variety of ranges. Includes dimensional drawing. Electronics Div, De-Jur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

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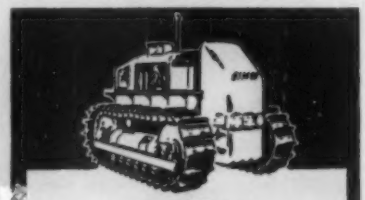

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INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

B

Balls 62
Bearings
Ball .....4th Cover, 5, 24, 53, 62
Miniature .....4th Cover, 11
Needle 53
Roller .....4th Cover, 53
Belts, V 50
Blowers 58

C

Cams 64
Casters 23
Castings 7
Chains
Conveyor 59
Roller 59
Control Panels & Switchboards..... 68
Couplers 67
Couplings
Hose 22
Tube 22

D

Drafting
Supplies 48
Drives
Hydraulic 64, 66
Shaft-Mounted 13
Variable Speed 13, 66

E

Engines 57

F

Fastening Methods 64
Fibre 26
Fittings, Hose, Pipe & Tube..... 22
Forgings 7

G

Gears .....2nd Cover, 2

H

Heating Units 63
Hydraulic Fluids 61

L

Lamps, Indicator 60
Laminated Plastics (see Plastics, Laminated)
Locks 64
Lubricants 61

M

Moldings
Plastics (see Plastic Parts)
Powdered Metal (see Powdered Metal Parts)
Rubber (see Rubber Parts)
Motors, A-C
Fractional 9
Integral 9, 13
Sub-Fractional 9
Motors, D-C
Fractional 9, 62
Integral 9, 13
Sub-Fractional 9
Motors, Hydraulic 64

N

Nickel Alloys 14

P

Plastic Parts 56, 66
Plastics 66
Plastics Laminated 26
Powdered Metal Parts 56

R

Reproduction Supplies 48
Rings 7
Rod Ends 5
Rubber Parts .....3rd Cover

S

Scales 62
Seals .....3rd Cover, 24
Special Shapes & Sections..... 7
Speed Increasers & Reducers..2nd Cover

T

Timers 55

V

Valves
Hydraulic 68

W

Wheels 23

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A
Acme Chain Corp. 59
Albion Industries, Inc. 23
Anchor Coupling Co., Inc. 22

B
Baldwin-Lima-Hamilton Corp., Standard Steel Works Div. 7
Barber-Colman Co. 62

C
Chicago Lock Co. 64
Cleveland Worm & Gear Co., Subs. of Eaton Mfg. Co. .....2nd Cover

D
Drillnut, Inc. 64
du Pont de Nemours & Co., (Inc.), E. I., Photo Products Dept. 48

E
Eagle Signal Co., Div. of Gamewell Co. 55
Electrofilm, Inc. 63
Eonic, Inc. 64

F
Falk Corp. 13

G
Gear Specialties, Inc. 2
General Electric Co., Miniature Lamp Dept. 60

H
Halex Corp., Subs. of Polymer Corp. .. 55
Hartford Steel Ball Co. 62
Heim Co. 5
Hydraulics, Inc. 66
Hyaroway Scales, Inc. 62

I
Industrial Electronic Engineers, Inc. .. 68
International Harvester Co., Construction Equipment Div. 57
International Nickel Co., Inc. 14

K
Kaydon Engineering Corp. 53

M
M-D Blowers, Inc., Subs. of Miehle-Goss-Dexter, Inc. 58
Miniature Precision Bearings, Inc. 11
Minnesota Rubber Co. .....3rd Cover

N
New Departure Div., General Motors Corp. 24

O
OPW-Jordan Co. 67

P
Polo Plastics Co. 66

R
Robbins & Myers, Inc. 9

S
SKF Industries, Inc. .....4th Cover
Shell Oil Co. 61
Society for Experimental Stress Analysis 67
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp. 7
Stratoflo Products, Inc. 68

T
Taylor Fibre Co. 26

U
U. S. Rubber Co., Mechanical Goods Div. 50

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F. J. Eberle, Business Mgr.
EMPLOYMENT OPPORTUNITIES 66

Index to Advertisers appears on P. 68
Products Index appears on P. 67

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2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

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REPRINTS

P36	P37	P38	P39	P40	P41	P42	P43	P44	P45
P46	P47	P48	P49	P50	P51	P52	P53	P54	P55

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365—Alloys, 8 pp, H K Porter Co Inc, Riverside-Alloy Metal Div.

366—Tool Steel for Cold-heading, 8 pp, Uddeholm Co of America Inc.

NON-METALLIC MATERIALS, FINISHES

358—Reinforced Plastics, 8 pp, Atkins & Merrill Inc, Reinforced Plastics Div.

367—High-temperature Urethane Foams, 3 pp, Carwin Co.

373—Thermosetting Materials, 2 pp, Fiberite Corp.

POWER TRANSMISSION

355—Variable-speed Drives, 6 pp, Link-Belt Co.

361—Parallel, V-ribber Belt Drives, 4 pp, Dayton Industrial Products Co.

MECHANICAL PARTS

351—Aluminum Boxes and Covers, 24 pp, Zero Mfg Co.

362—Adjustable Industrial Closures, 4 pp, Moeller Mfg Co Inc.

363—Beaded Chain and Small Swaged Parts, 4 pp, Auto-Swage Products, Inc.

MOTORS, ENGINES AND CONTROLS

350—Ac Motors, 56 pp, Sterling Electric Motors Inc.

357—Motor Selector, 8 pp, Howell Electric Motors Co.

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GENERAL ENGINEERING

322—Single Plane Strain Gage

329—Arc Ruler

330—Stick Construction Kit

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302—Large Single Crystals of Refractory Materials

311—Graphitic Tool Steel

POWER TRANSMISSION

301—Centrifugally-operated Clutch

304—Packaged Precision Drives

310—Miniature Electric Brakes

313—Fin, Fan-cooled Speed Reducer

315—Miniature Gear Reducers

MECHANICAL PARTS

305—Miniature Vane Axial Blower

316—Viton-to-metal Bonded Seals

324—Digital Transducers

327—Electronic Chassis Slide

FASTENING AND JOINING

312—High-temperature Bolt

MOTORS, ENGINES AND CONTROLS

325—Size 8, 115 v Servomotor

326—Size 23, Servomotor-generator

ELECTRICAL, ELECTRONIC COMPONENTS

300—Angular Motion Transducer

303—Sealed Temperature Control

307—Miniature Toggle Switch and Circuit-break Combination

309—Silicon Bridge Rectifier

318—Subminiature Elapsed-time Indicator

319—Potentiometer Pressure Pickups

320—Strain Gage Pressure Pickup

321—Lighted Oiltight Pushbutton

323—Small-diameter Solenoid

328—Time-speed Recorder

HYDRAULIC, PNEUMATIC EQUIPMENT

306—Packless Valve

308—Filler Cap With 30-mesh Screen

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ELECTRICAL, ELECTRONIC COMPONENTS

353—Solid-state Timing Modules, 16 pp, Tempo Instrument Inc.

354—Dry Batteries, 22 pp, Marathon Battery Co.

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356—Lubricating Equipment, 8 pp, Oil-Rite Corp.

359—Hydraulic Components, 6 pp, Denison Engineering Div, American Brake Shoe Co.

364—Heat-reactive Tubing, 4 pp, Minnesota Mining & Mfg Co.

368—Rotary Gear Pump, 6 pp, Sier-Bath Gear & Pump Co.

370—Sliding-gate Pressure Regulators, 8 pp, OPW-Jordan

374—Heat-transfer Oil, 2 pp, Sun Oil Co, Industrial Products Dept.

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3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P36	P37	P38	P39	P40	P41	P42	P43	P44	P45
P46	P47	P48	P49	P50	P51	P52	P53	P54	P55

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3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
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20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

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P36	P37	P38	P39	P40	P41	P42	P43	P44	P45
P46	P47	P48	P49	P50	P51	P52	P53	P54	P55

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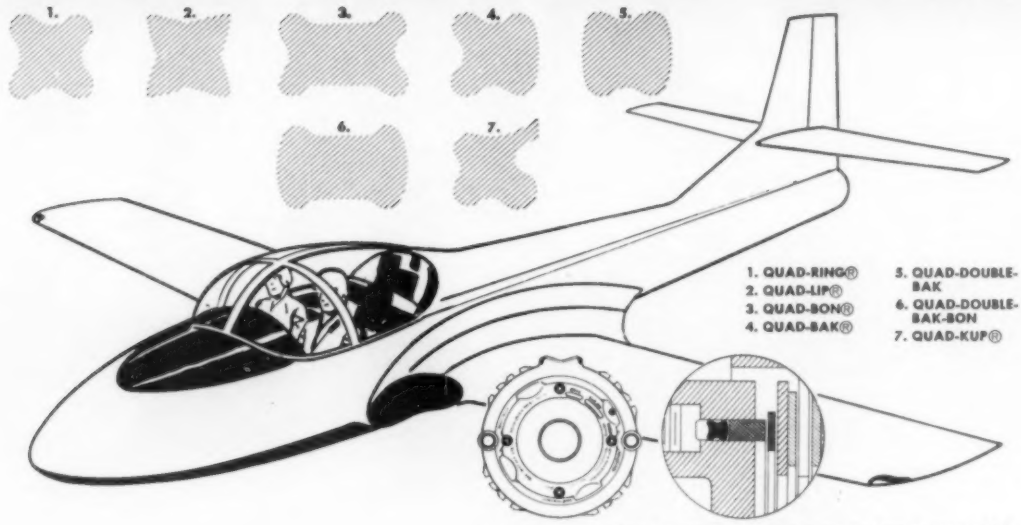

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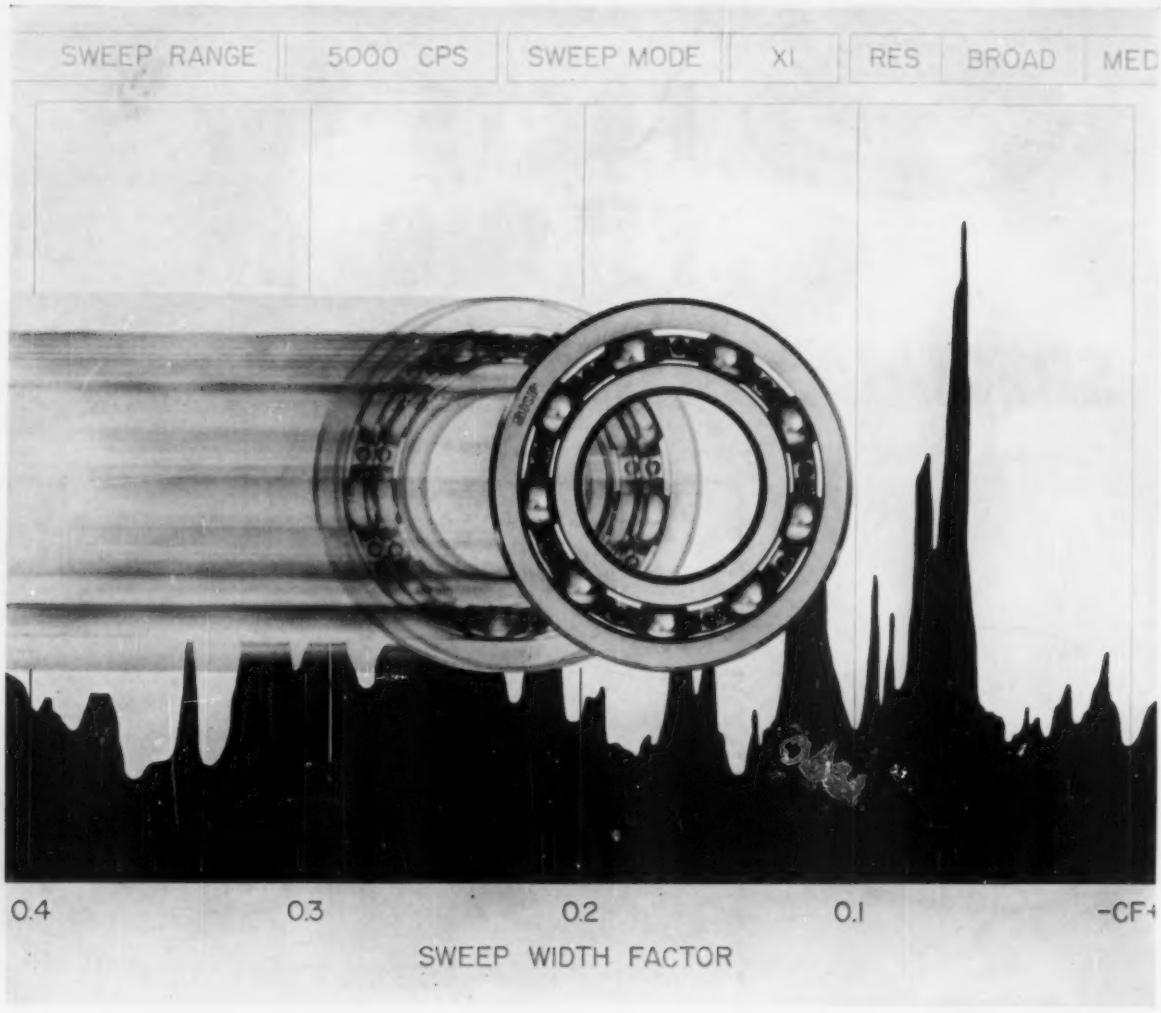

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Every bearing meets new, more critical standards. Each type and size meets special requirements for reduced vibration. Every ball meets very low waviness limits. Each cage meets critical standards for smooth, quiet performance.

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